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JOURNAL

VOLUME 13, NUMBER 9 • SEPTEMBER, 1957

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Plastics Provide Protection Against Radioactive Contamination

PUBLISHED BY THE SOCIETY OF PLASTICS ENGINEERS, INC.

ANNOUNCING the PE-175 molding machine by WATSON-STILLMAN

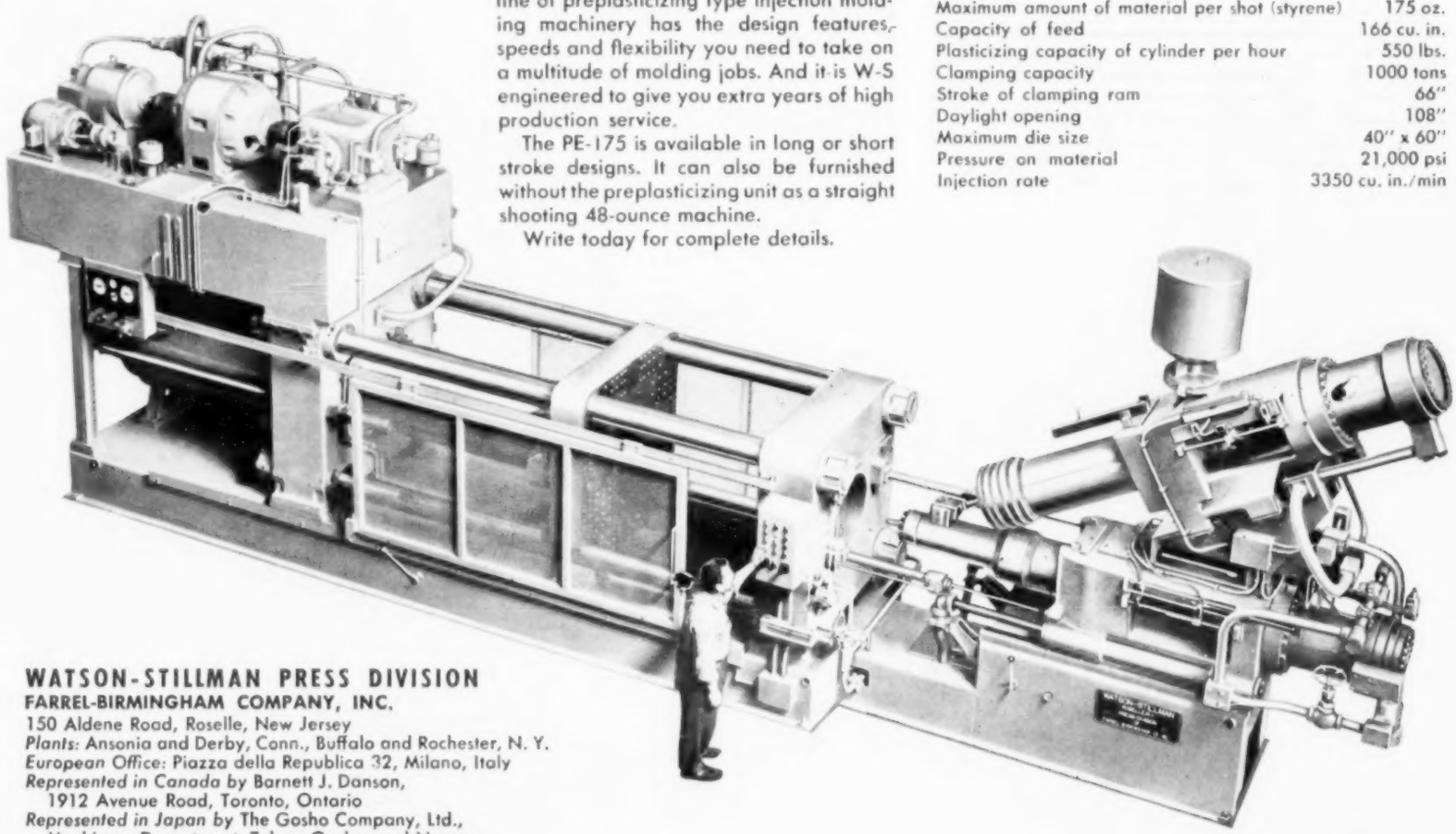
This latest addition to the Watson-Stillman line of preplasticizing type injection molding machinery has the design features, speeds and flexibility you need to take on a multitude of molding jobs. And it is W-S engineered to give you extra years of high production service.

The PE-175 is available in long or short stroke designs. It can also be furnished without the preplasticizing unit as a straight shooting 48-ounce machine.

Write today for complete details.

SPECIFICATIONS (long stroke machine):

Maximum amount of material per shot (styrene)	175 oz.
Capacity of feed	166 cu. in.
Plasticizing capacity of cylinder per hour	550 lbs.
Clamping capacity	1000 tons
Stroke of clamping ram	66"
Daylight opening	108"
Maximum die size	40" x 60"
Pressure on material	21,000 psi
Injection rate	3350 cu. in./min



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WATSON-STILLMAN

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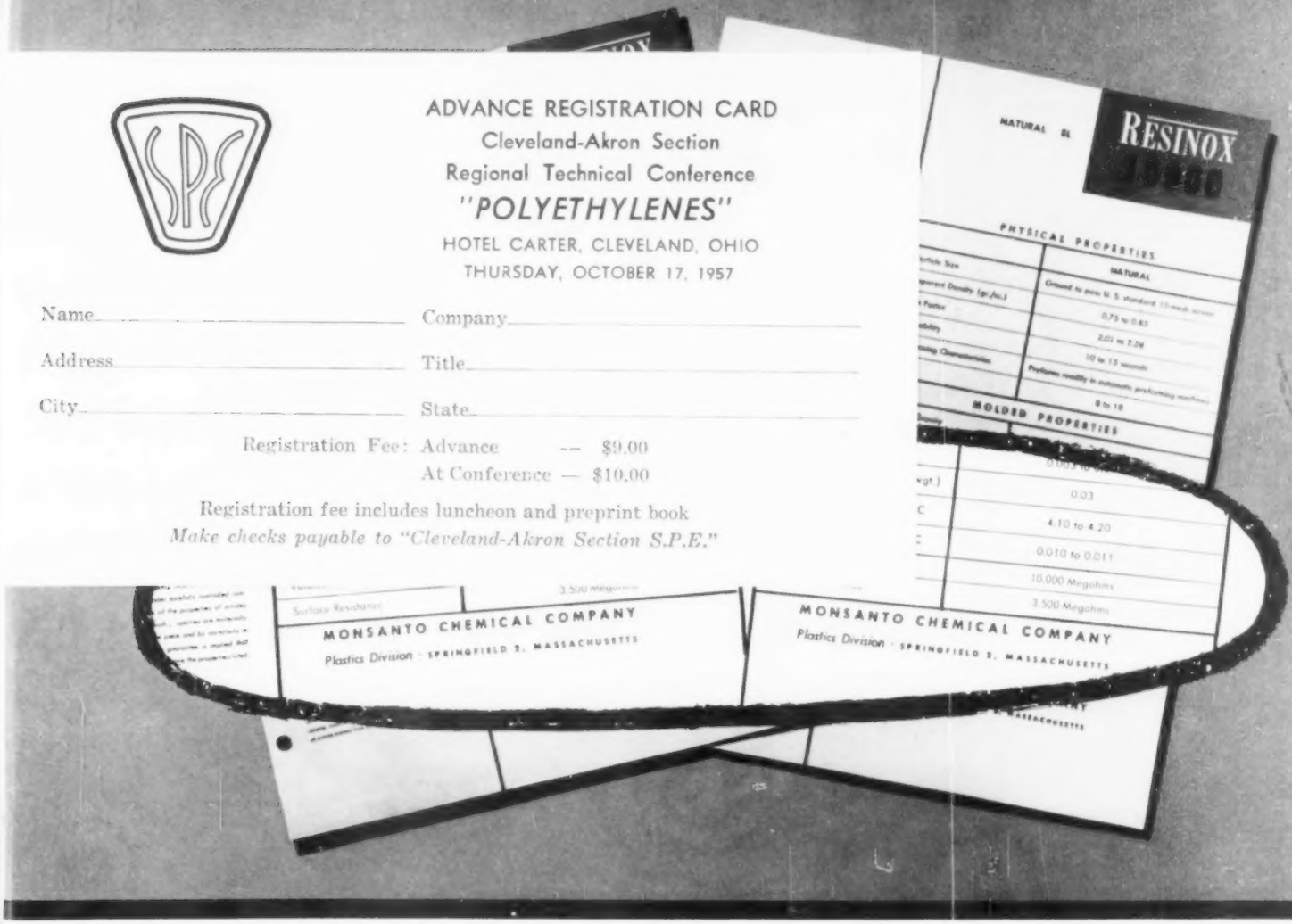
FOR LOW-LOSS HIGH FREQUENCY APPLICATIONS

RESINOX 7934 AND 10900 SET THE STANDARD



In the vital properties that determine good performance in low-loss high frequency applications (such as water absorption, power factor) data sheets on 7934 and 10900 speak for themselves.

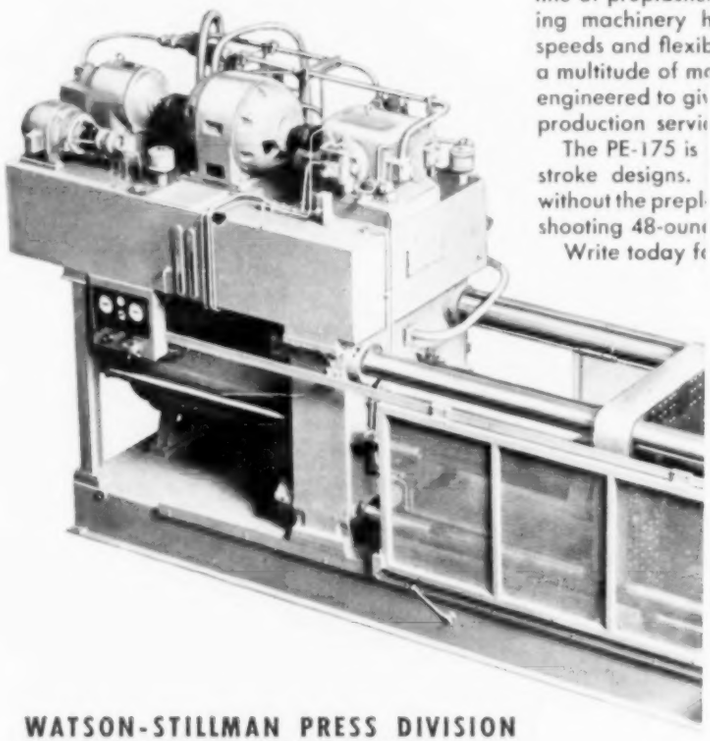
Formulated to meet MIL-M-14E specifications for type MFE (electrical low loss phenolic), Monsanto's mica filled phenolic compounds continue to set the standard for end use performance in such applications as radio tube sockets, connectors, and capacitors.

New improvements in molding characteristics clear the way for still wider use for these molding compounds.

Now is the time to re-examine Resinox 7934 and 10900 for your communication parts and television components. Write for samples and complete technical data to Monsanto Chemical Company, Plastics Division, Room 1877 Springfield 2, Massachusetts.

Monsanto

ANNOUNCING the PE-175 molding machine by WATSON-STILLMAN



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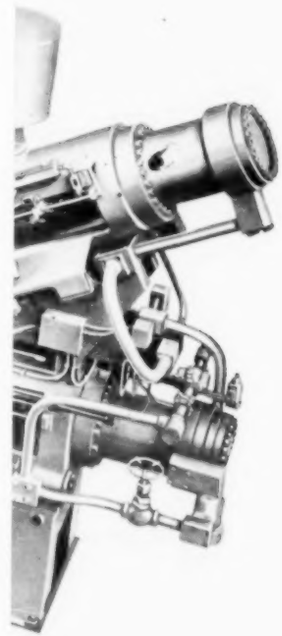

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U.S.I.

Vol. II, No. 5

POLYETHYLENE PROCESSING TIPS

HOW CARBON BLACK QUALITY AFFECTS WEATHER RESISTANCE OF POLYETHYLENE

For cable jacketing and many other outdoor applications polyethylene offers substantial advantages over other materials. It is subject, however, to degradation from long exposure to sunlight unless the resin is properly protected.

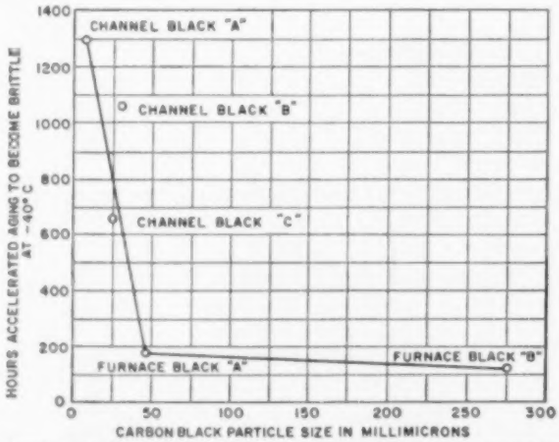
Actually, the aging of polyethylene is the result of a chemical reaction with atmospheric oxygen. Catalyzed by the ultraviolet rays in sunlight, this reaction proceeds more rapidly in outdoor use than is the case with indoor applications. The principal effects of aging are to increase brittleness at low temperature, and to decrease the resistance to stress cracking.

Carbon black dispersed throughout the polyethylene greatly retards this aging, or weathering. However, not all carbon blacks produce the same degree of weather resistance when dispersed in polyethylene. Moreover, the care with which the carbon black is dispersed in the polyethylene is vitally important.

The weather resistance of a polyethylene compound depends on: (1) type and particle size of carbon black; (2) percentage of carbon black in the compound; (3) the dispersion of the carbon black in the polyethylene.

Accelerated aging tests have been devised to approximate the action of years of outdoor exposure.

The graph below shows the great difference in number of hours required in these tests for a polyethylene to embrittle at −40°C when various carbon blacks having different particle sizes are used.



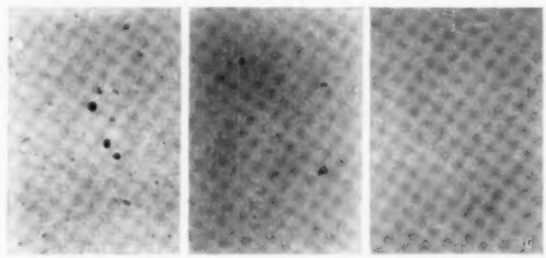
EFFECT OF CARBON BLACK PARTICLE SIZE ON ACCELERATED AGING OF POLYETHYLENE.

The two at right are "furnace blacks", and it will be noted that they are comparatively ineffective. The three at the left are "channel blacks", and obviously, they are many times more effective. This is due to their much smaller particle size – from about 10 to 25 millimicrons, against 50 to 275 millimicrons for furnace blacks.

Weather resistance also increases with the concentration of carbon-black – up to a point. Beyond this point the light screening effect is offset by a decline in other properties.

DEGREE OF DISPERSION IMPORTANT

Carbon black gives maximum protection only when it is thoroughly dispersed in the polyethylene. This presents a difficulty because the smaller the particles, the greater is their tendency to collect into clusters which, once formed, are hard to break up. Tests show that a good dispersion will withstand 15 to 20 times as much exposure to sunlight as a poor dispersion.



POOR FAIR GOOD

MICROPHOTOGRAPHS OF CARBON BLACK DISPERSIONS IN POLYETHYLENE.

The wire and cable grades of U.S.I.'s PETROTHENE polyethylene resins employ only the finest "channel black" carbon black. Concentration is set at a point which yields the optimum balance of light screening and other properties. Special processing equipment insures thorough dispersion. The result is black polyethylene that withstands long, severe outdoor exposure, yet affords the practical maximum of tensile and other properties.

If you fabricate or use black polyethylene, ask U.S.I. for complete technical data on PETROTHENE resins expressly formulated for weather resistance.

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SPE JOURNAL

VOL. 13 SEPTEMBER, 1957 NO. 9

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An all-plastic model car believed to be the first of its kind in the automotive industry is assisting Chrysler Corporation engineers to determine the sturdiness of automobiles. The six-foot long, transparent plastic model, is an exact replica, three-eighths the size of a standard steel automobile. It allows engineers to check data on the structural strength of body shells, underbodies and other key parts of a car.

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Five

TOMORROW'S PRODUCTS TODAY...THROUGH ENJAY PETROCHEMICALS

Basic raw materials for **VINYLS** that open up a new world of toys!

Children love the light weight and gay colors of vinyl surf mats and countless other vinyl toys. The quality of these popular end products depends to a large degree on the quality of the plasticizers used in their manufacture.

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Each geographical Section of the Society shall use only such uniform stationery, forms, etc., as shall be approved by the Council and as may be supplied through the Executive-Secretary of the Society.

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From The Editor's Notebook

By JESSE H. DAY

ATTENTION! ROSTER ISSUE CHANGE!

Pages 87 and 88 of your Roster issue, June 1957, somehow were transposed. To correct it, change page numbers with your pen, and at the top of page 87 (old number) write "Western New England."

● ● ●

Calendar of SPE Technical Meetings

REGIONAL TECHNICAL CONFERENCES
(Programs listed on pages 52-53)

SEPTEMBER 27, 1957 — Buffalo, New York —
"HOT RUNNER MOLDING" sponsored by Buffalo Section.

Chairman—R. W. Miller, 3 Hillview Ct., Lewiston, N.Y.

OCTOBER 8, 1957 — Minneapolis, Minnesota —
"ISOCYANATES" sponsored by Upper Midwest Section.

Chairman—Paul Becker, 1139 Carl St., St. Paul 9, Minn.

OCTOBER 17, 1957 — Cleveland, Ohio —
"POLYETHYLENES" sponsored by Cleveland-Akron Section.

Chairman—W. A. Messina, 23817 Cliff Dr., Bay Village, Ohio.

NOVEMBER 11, 1957 — Los Angeles, California —
"PLASTICS IN AIRBORNE ELECTRONICS" sponsored by Southern California Section.

Chairman—L. J. Costanga, 29 East 44th St., Los Angeles 58, Cal.

DETROIT THIRD ANNUAL CONFERENCE

SEPTEMBER 27-28—St. Clair, Michigan—
"PLASTICS FOR THE AUTOMOTIVE INDUSTRY" sponsored by Detroit Section

ANNUAL TECHNICAL CONFERENCE

JANUARY 28-31, 1958 — HOTEL SHERATON-CADILLAC, Detroit, Michigan. Sponsored by Detroit Section.

—Featuring 96 Scientific and Engineering Papers on Plastics Research and Education Symposia—

CONFERENCE THEME — "Progress Through Plastics Engineering"

Chairman—C. H. Whitlock, 21655 Coolidge Road
Oak Park, Michigan

This Month's Cover:

The "Man from Mars" on your cover this month is a plain human being prepared to do a dangerous job. The suit is of plastic film, connected to a large plastic film tube through which ventilation is possible. The job — to enter spaces contaminated by radioactivity. The story—see page 21.

THE MARK OF QUALITY

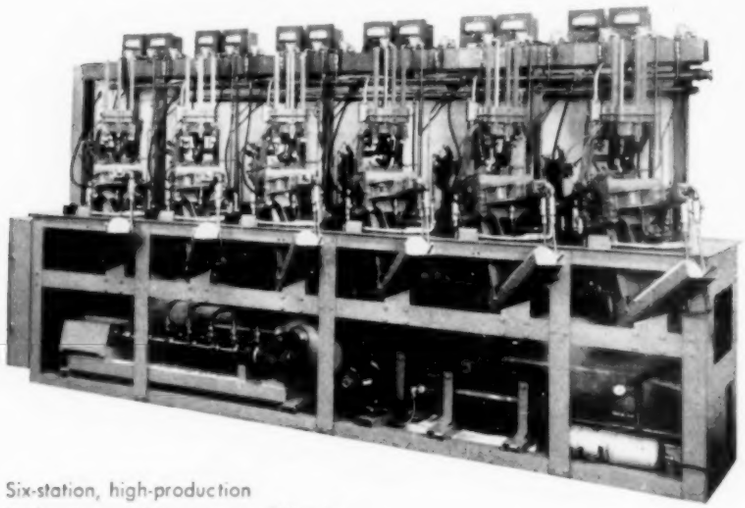
BARBER COLMAN

Wheelco Instruments

Mold temperature controlled "on the button" to keep plastic lid output high

Precise control of mold temperatures is a must on this Model EM-132 plastic lid-forming machine built by Emhart Mfg. Co., Hartford, Conn. The transparent plastic lids come shooting out of the machine at the rate of 90 per minute or more, so every machine function must be "on the button" to keep quality and quantity standards high.

Like so many other builders of quality machinery for the plastics industry, Emhart selected Wheelco Capacitrols to give fast and accurate control of mold temperatures and to insure trouble-free operation for long periods. Wherever you go throughout the plastics industry, whether the job calls for high-volume production of small parts like these or requires work on large, complex components, you'll find Wheelco instruments are always preferred. Learn the reasons why by writing today for Bulletin F-6485, "Capacitrols for the Plastics Industry."



Six-station, high-production lid-forming machine uses two Wheelco Capacitrols at each station for precise mold temperature control.

BARBER-COLMAN COMPANY

Dept. U, 1575 Rock Street, Rockford, Illinois, U.S.A.

BARBER-COLMAN of CANADA, Ltd., Dept. U, Toronto and Montreal, Canada

CRUCIBLE CSM 2 mold in press at Pro-phy-lac-tic Brush Co., Florence, Mass. The mold, built by Eagle Tool & Machine Co., Hillside, New Jersey, produces vegetable pans for Hotpoint refrigerators.

why **CRUCIBLE CSM 2**

is chosen for so many big molds . . .

One reason is that CRUCIBLE CSM 2 is always uniform in structure and composition. It's got to be. For the quality of every *heat* is controlled by Quantometer analysis . . . and every *piece*, regardless of size, is ultrasonically inspected. This means superior machining and polishing characteristics.

Another reason is that CRUCIBLE CSM 2 is immediately available from *warehouse* stock in 205 sizes, big and small. The job isn't held up for steel when you order CSM 2, the mold steel you can *trust* and get *when* you want it. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

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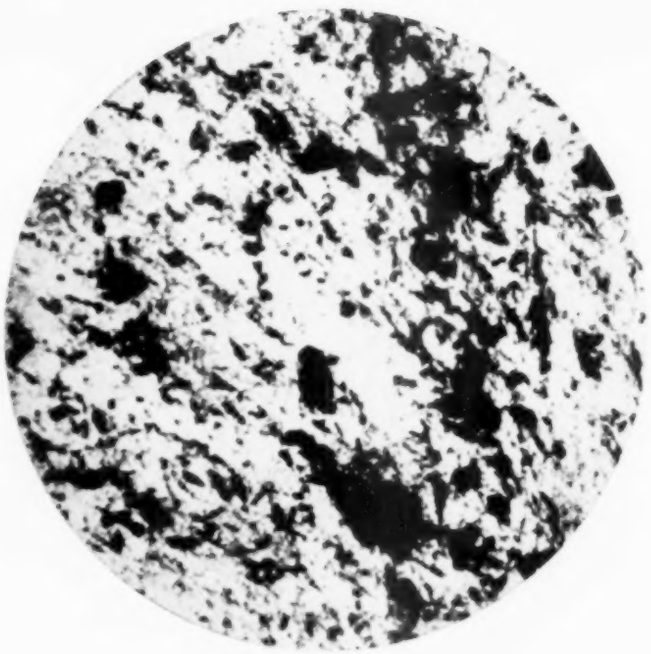
Are your troubles caused by poor dispersions?



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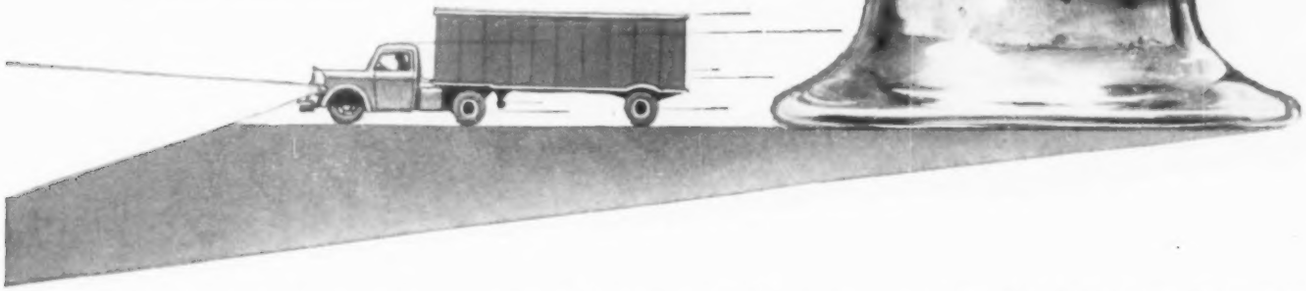

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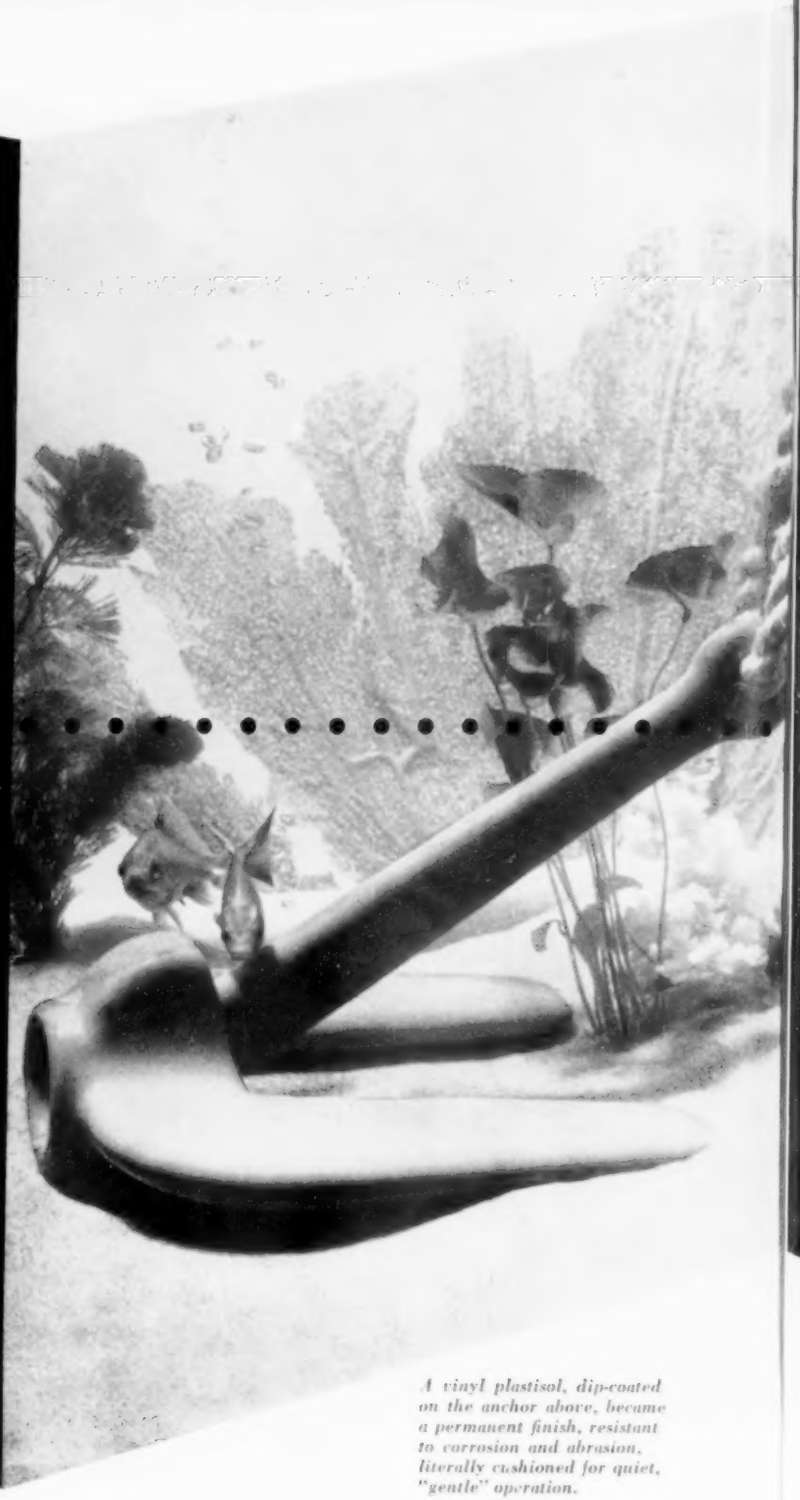
The broad Monsanto series of Vinyl resins and compounds



A vinyl plastisol, dip-coated on the anchor above, became a permanent finish, resistant to corrosion and abrasion, literally cushioned for quiet, "gentle" operation.

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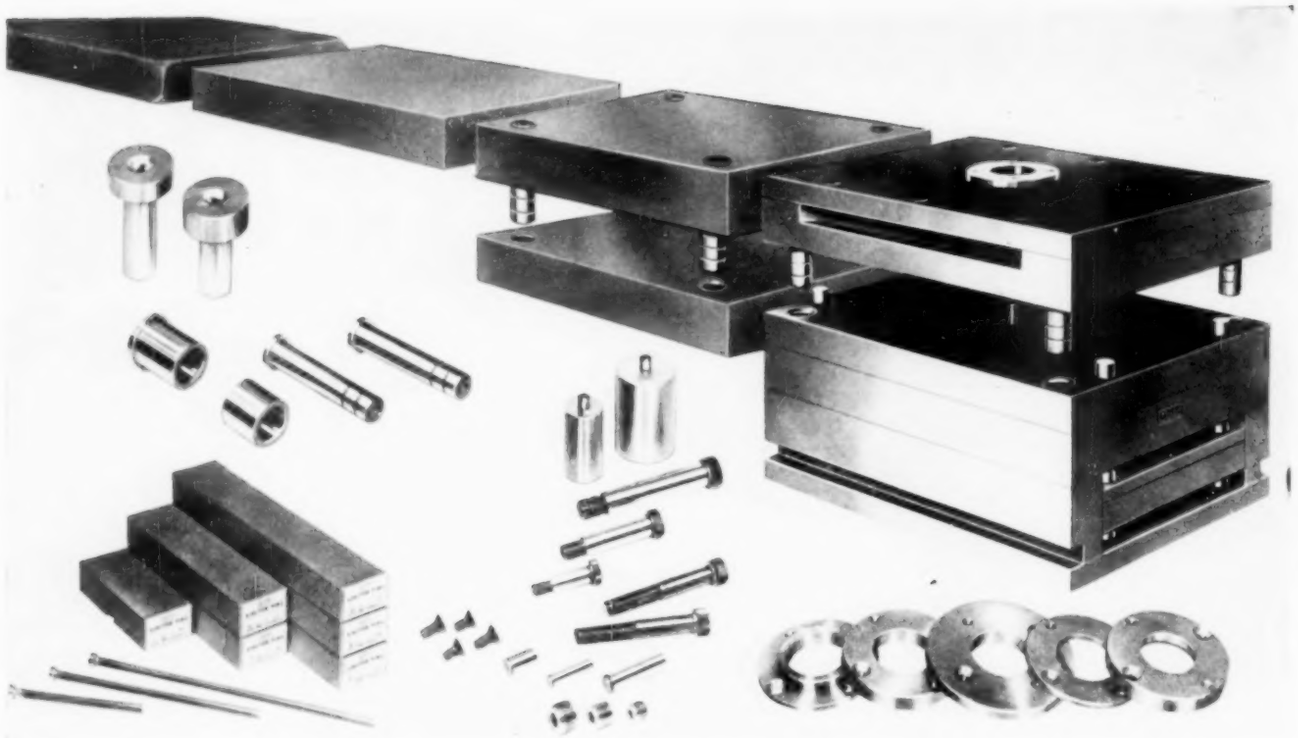

PROGRESS THROUGH STANDARDS

. . . and how DME "helped"

The history of economy in modern business has been directly related to the history of Standardization. One of the major elements affecting the economic production of finished plastic parts is the high initial cost of the mold. A progressive step in reducing mold cost, without sacrificing the high quality required, has been successfully achieved through Standardization.

When D-M-E originated Standard Mold Bases and their component parts in 1942, it provided the answer to the rapidly growing demand for high quality molds that would maintain and promote the economic advantages of plastic parts.

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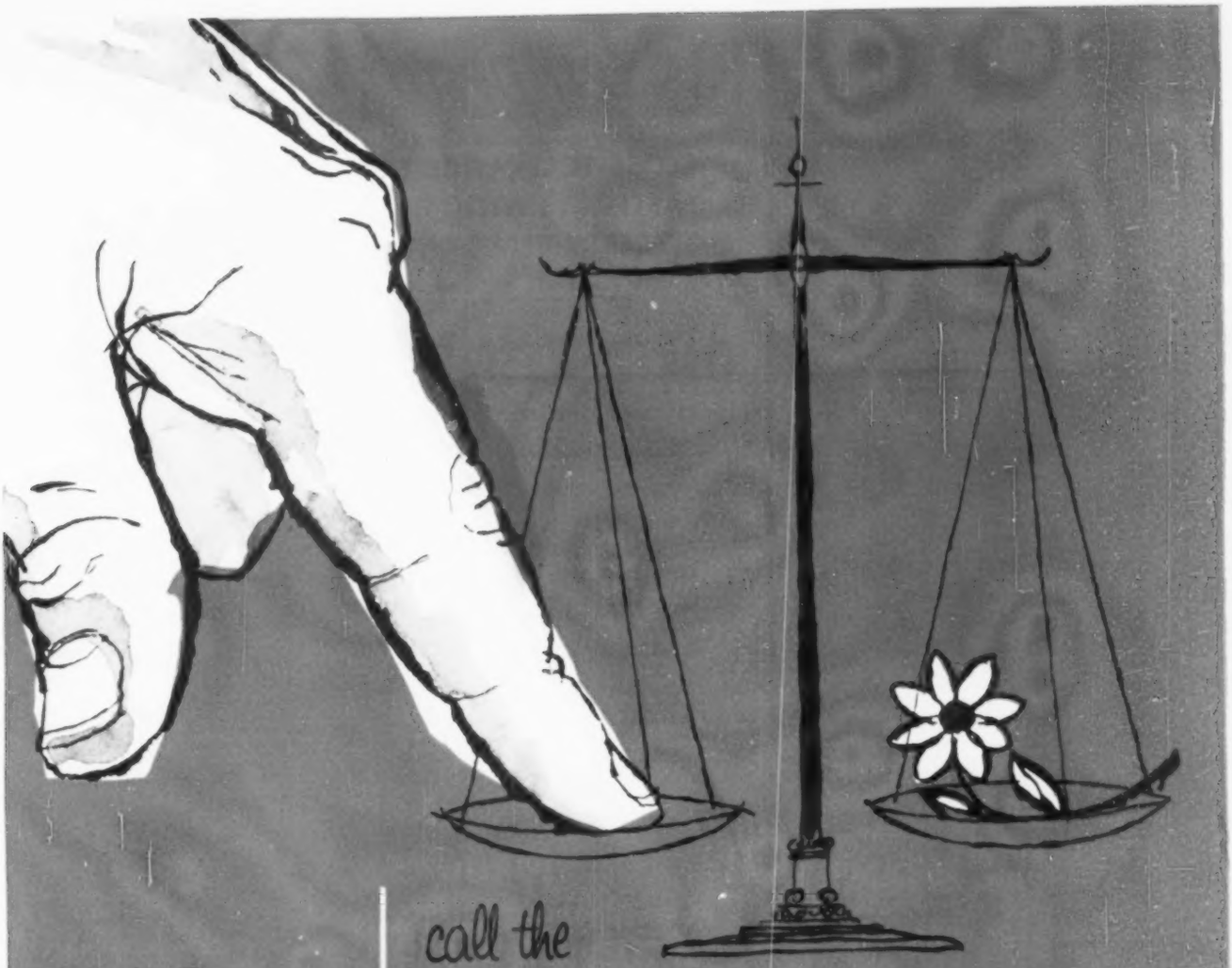

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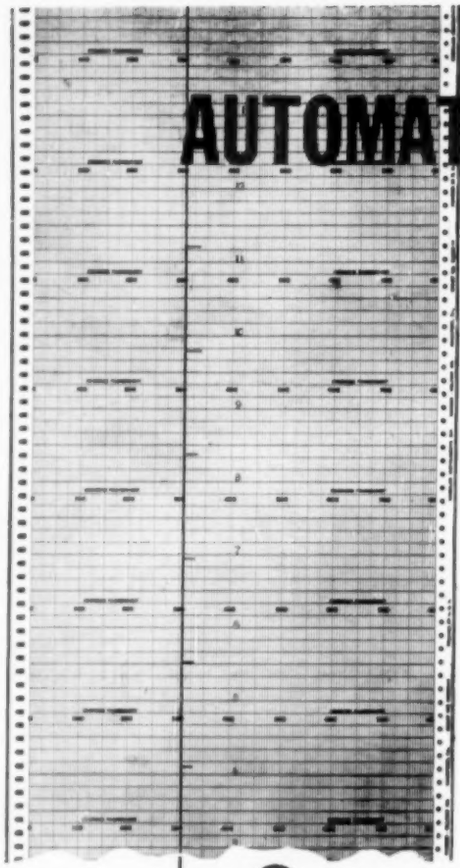

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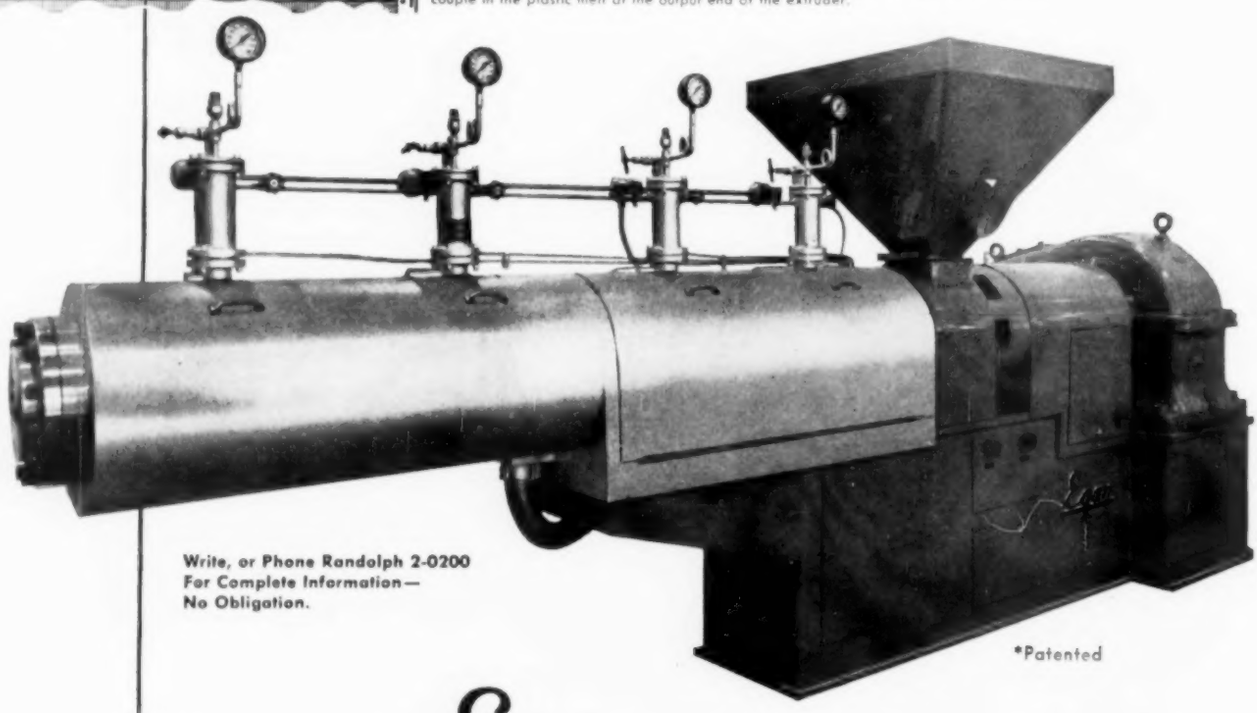

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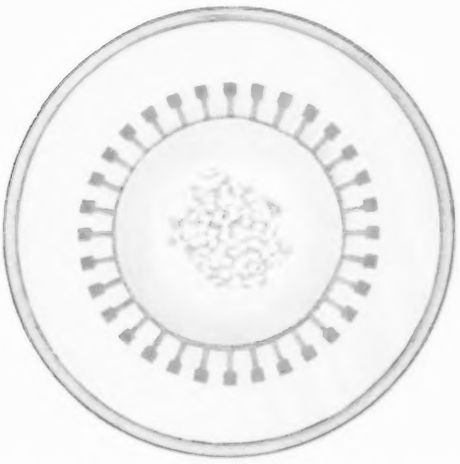
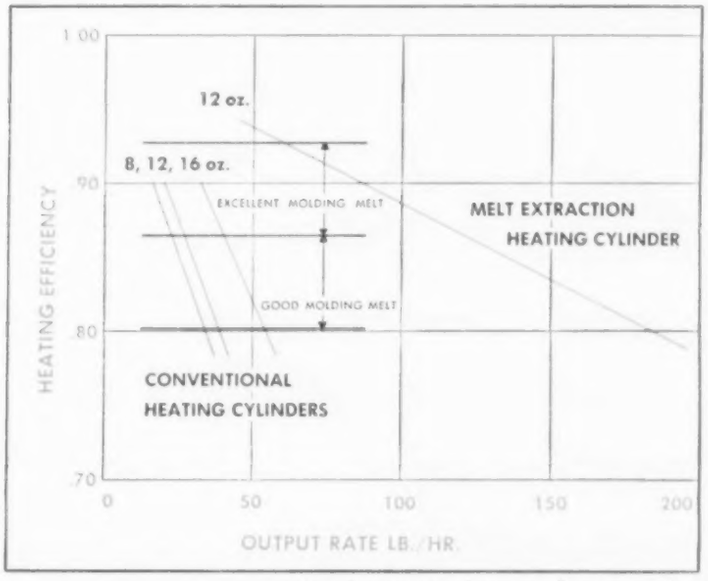
Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

PLASTIC STOCK TEMPERATURE CRITICAL FACTOR IN INJECTION MOLDING



Melt extraction heater, above, is a cylindrical device with exterior longitudinal grooves. Bottom of each groove has many perforations to provide passage to the groove. When cold plastic granules enter center of liner, they touch hot wall, melt and flow through holes to the groove and then forward to injection nozzle. Device replaces the torpedo of a conventional heating cylinder.



A melt extraction heater produces more than three times as much melted plastic at 0.8 efficiency as an average conventional heater of comparable size.

INCREASED EFFICIENCY OF MELT EXTRACTION HEATERS PROVIDES UNIFORMLY PLASTICIZED MOLDING MATERIALS

Melt extraction heating of thermoplastics shows promise of overcoming a long-recognized problem for injection molders . . . that of providing a steady flow of uniformly plasticized material to the mold cavity. The design of a melt extraction heater eliminates the need to transfer heat through the plastic. Uniform temperature distribution in the plastic is assured because the means of removing the plastic from the heated surface restricts the material removed to that which is well melted (see illustration above). When the plunger exerts pressure on the granules, the fluid polymer next to the inside surface of the liner flows through the holes into the grooves and through the nozzle to the mold.

The advantages of providing uniformly plasticized material are several. Silver streaking, caused by overheating in localized areas can be eliminated. And discoloration and brittleness of plastic parts, associated with degradation of the polymer, may be reduced with uniformly plasticized material.

The design and development of more efficient melt extraction heaters is one area now under study by Dow Plastics Technical Service engineers.

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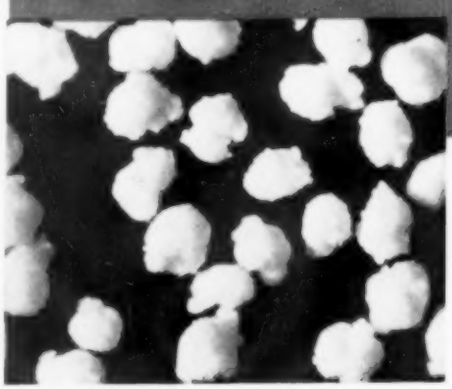

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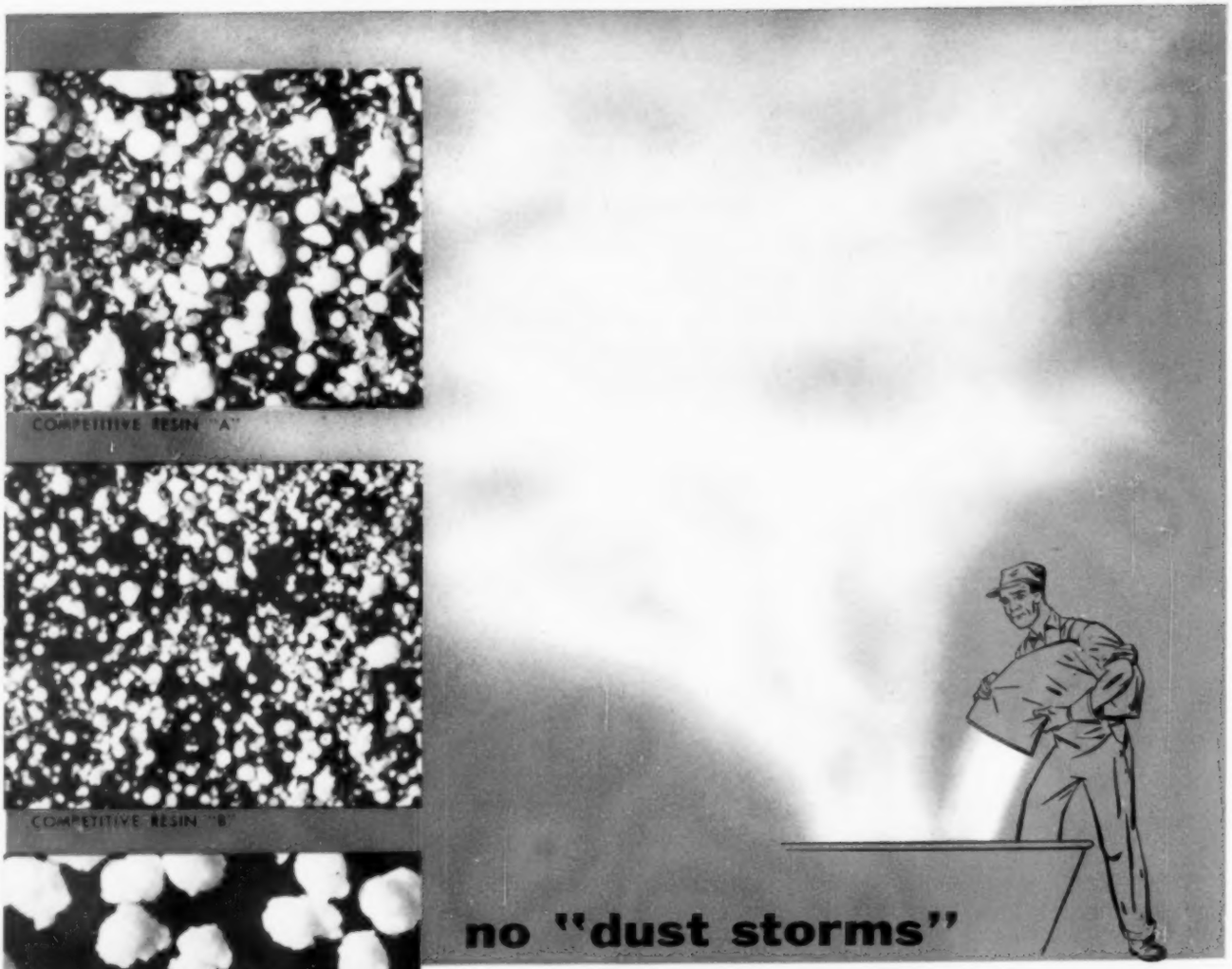

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Flexible Plastics for Control of Radiation Contamination

H. A. Moulthrop

General Electric Co.
Hanford Atomic Products Operation
Richland, Washington

ONE TYPE of radiation hazard encountered in atomic energy work is associated with the soft beta and the alpha emitters. This type of hazard is associated mostly with chemical separation of fission products and as such is a problem of major atomic energy plants such as Hanford or Savannah River, rather than industrial type reactors.

The alpha particles emitted from substances such as plutonium are potentially dangerous. Their radiation will not penetrate a single sheet of thin paper, but the introduction of even microscopic particles of such materials into one's body can result in serious injury or death by destruction of blood-forming cells or vital organs. It is this field of atomic energy work with its tremendous potential for plastic applications that is discussed in this article.

An indication of the precautions which are required against this second type of radiation hazard is the protective clothing which has been commonly used in those areas where introduction of radioactive material into the body by ingestion or skin contact is a possibility. Shown above, is a worker with his multi-layered clothing in readiness to enter a radiation zone. This philosophy of protection is based on wearing sufficient clothing to insure that clothing nearest the skin is never contaminated and it presumes that the outer layers will become contaminated. Generally the contamination is so great that much of the protective apparel cannot be reused.

A second serious disadvantage associated with this type of radiation hazard is the curtailment of operations resulting from maintenance work on equipment where such hazards are involved. This comes about from the fact that radioactive dust and vapor commonly escape whenever any opening is made in an equipment enclosure where radioactive materials are present. Such openings not only create a problem by contaminating the clothing of the workers, but also contribute to spreading contamination into the surrounding process area. This in turn requires tedious decontamination of the area immediately around such an enclosure opening before normal work outside of the equipment enclosure can be resumed. For the preparation which must be made in the process area before beginning radioactive maintenance work through an open panel, all equipment is removed from the operating cell and the entire floor area together with the hood and walls must be covered with paper. This is done to permit escaped contamination to be more readily removed at the end of the job. Much time and

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This paper is a condensation of the paper presented at the 13th SPE Technical Conference.

Figure 1. Older type of protective clothing.

Figure 2. Plastic glove inlets to reach equipment in danger zone.

Figure 3. Man-size plastic tube allows protected entry through port.

materials are required in preparing for and in cleaning up after any such maintenance activity. The most serious disadvantage, though, is the lapse of production which must result while the entire operation is closed down. Yet, with open panel methods of contact maintenance this loss was necessary to insure protection of the workers and to minimize the spread of contamination which can result from even small size maintenance jobs.

The Problems

Such were the problems which confronted the production of plutonium and similar atomic energy products during the earlier days of the industry. Contamination could be confined within prearranged barricades and enclosures during normal performance of equipment, but the improvement in efficiency depends on fewer process interruptions. It became evident that some method must be found to improve the efficiency of the operation with respect to maintenance activity. It also became apparent that to obtain the mandatory radiological protection without seriously sacrificing operating efficiency by frequent equipment shutdowns, it would be necessary to perform maintenance work on minor items of enclosed equipment and to make material transfers across the barrier as represented by the walls of the equipment enclosure without actually opening a hole in the barrier wall.

A number of years ago a plastic item introduced as a possible solution to this problem was a small bag made of flexible polyvinyl chloride and sealed on all sides except for one end. This open end is attached to an elastic cord which permits it to be stretched over a protruding ring on the side of the process enclosure. Being made of polyvinyl chloride, it is possible to seal the bag electronically using a jaw type sealing bar. Materials inserted into the end of the bag can thus be separated from the remaining portion of the bag by tear sealing. This permits removal of the material from the process enclosure without creating any opening in the contamination barrier. Since this method successfully confined all radioactive materials, it precluded the need for protecting the entire area of the room.

Use of Plastic Bags

This philosophy was quickly adopted and the later types of process hoods have many access ports located on the surface of the hood. Some of these which are used have plastic bags for material transfers and others have gloves for permitting manual work on equipment inside the enclosure.

Operating philosophy at this stage of development was one of maintenance from the outside of the hood through rubber gloves with introduction and removal of materials through plastic bags. Although this method of operation was a tremendous advance over previous philosophy it still presented problems of its own. These may be symbolized by Figure 2 where you see an operator attempting to reach with the finger tips of one hand, some item of defective equipment. The interrelated layout of equipment in the hood prevented locating the item at an optimum distance for easy access. Frequently physical limitations prevented installing process equipment within easy reach of the operator through access ports from outside the hood. This often resulted in vital items of equipment being obscured from the operator's view by interposed piping which could not be located elsewhere. If the hood was constructed too wide equip-

Figure 4. Large plastic "sock" is entered, then worker turns it inside out by entering port into radioactive work space—where he is protected by the plastic.

ment could not be reached. Yet, if it were made more narrow for arm accessibility through glove ports the equipment became congested and removal of any single item without disturbing others became a problem. In many cases panels on the walls of the hoods still had to be moved to permit adequate accessibility or to allow necessary transfer of equipment to and from the process enclosure.

Plastic Sheeting

Plastic sheeting was now available and whenever the need for removing panels arose, it was used to advantage in curtailing contamination spread. The precautions associated with open panels continued to restrict overall operating efficiency.

The availability of flexible plastic sheeting at this stage of atomic energy development permitted one distinct advantage over previous methods. Once the work of changing the panel was completed it was now possible through the use of the flexible plastic to do the necessary work through a large plastic covering over the opening. As familiarity with the use of plastic developed, the length of these coverings tended to increase until they resembled a short tunnel with viewing plates and gloves attached at convenient locations. The significant point was that normal operations could now continue within the operating cell while repair work was performed through the plastic panel.

It was a natural consequence that the access port for introduction of arms through the wall of the enclosure should be combined with repair work through panels to make the operation shown in Figure 4 a commonplace. Here we see the access ports expanded to diameters sufficient to permit the ready passage of personnel who were enclosed in a suit at the end of a tunnel. In this picture the tunnel has been doubled backwards into the area outside the hood. The worker is being assisted as he enters the tunnel. In the picture is also shown the smaller tunnel which connects to a blower and extends into the larger tunnel. This provides the worker in the tunnel with adequate ventilation. This development eliminated the previous problems of contamination spread experienced while removing panels from hood walls to repair equipment inside.

He is about to climb through the access port into the suit which is attached to the end of the tunnel and is lying just inside the hood wall. The worker, having entered the hood and fitted himself into the suit at the end of the tunnel, can assist another worker in the loading out of the defective equipment or waste from the inside of the hood through another access port.

A new tunnel or bag can be installed over the old one by gradually moving the elastic cord of the old one forward on the access port ring while working through the plastic of the new tunnel. The old tunnel at this point falls from the access port but within the new tunnel. The new tunnel now forms the contamination barrier replacing the old one.

Early Improvement

One of the first improvements which was made in the original development was the application of window clear flexible plastics. Recognizing the tremendous need for maximum visibility, an urgent effort was made during the earlier days of development to obtain transparent flexible plastic, but none was available. This resulted in the need for glueing and taping of non-flexible transparent sheeting to the flexible fabrics of the suits and tunnels. This left much to be desired, because of the frequent tendency of the glue or tape to give way under pressure, loosening the viewing plates and permitting contaminants to enter the suit. The appearance of transparent cast films on the market finally corrected this through the use of an all window headpiece.

Many subsequent changes followed in rapid succession, such as a swept-back head design using the transparent plastic. With this design the operator is not required to introduce his head into the suit as a specific operation. It also permitted better ventilation of his

(Please turn to page 66)

Synthetic Fiber Reinforced Thermosetting Resins

John G. Green, Jr. and George W. Mays

E. I. du Pont de Nemours & Co., Inc.
Wilmington, Delaware

. . . the growing acceptance and diverse use of plastic products has created a need for reinforcing materials which will satisfy the increasing and varied demands of the industrial and consumer markets. This need for improved or different property characteristics led to research in plastics reinforced with synthetic fibers. Nylon, Dacron *polyester fiber, and Orlon* acrylic fiber were investigated to determine their utility in satisfying the needs of this expanding market. It has been demonstrated that each of these fibers can improve the usefulness of the reinforced plastic by providing significant product improvements in electrical, chemical, mechanical, and aesthetic properties . . . .

Nylon, Dacron, and Orlon are available as cut staple fibers. In addition, nylon and Dacron are available as continuous filament yarns. These fibers are used by weavers to produce woven and non-woven fabrics for the reinforced plastics industry.

A variety of woven fabrics is produced, each of which has its own characteristics. It is necessary to consider both the fiber and fabric properties in selecting the most suitable candidate for a reinforcing application.

Nonwoven fabrics are receiving an increasing amount of attention by the reinforced plastics industry. Mechanical needling, or bonding with resin or thermoplastic fibers are the most common methods used in manufacturing nonwoven structures. Needled batts, which are mechanically bonded structures, are being used extensively in our research and development work. Needled batts of synthetic fibers provide a reinforcement with uniformity, strength, and tailorability in a wide range of weights and densities. The good tailorability, inherent bulk, and extensibility of these structures make them particularly adaptable to molding complex shapes with sharp corners.

Laminates — Properties and Applications

In the discussion of fibers and fabrics it has been pointed out that nonwoven needled batts of synthetic fibers have unique and desirable characteristics. Let us now examine some of the special properties of laminates reinforced with synthetic fiber needled batts and see how these properties have been successfully applied in industry. The laminates which will be discussed were produced in heated, matched-metal molds under identical conditions of 100 pounds per square inch pressure and 120 degrees C temperature. The resins used were general-purpose polyesters, unless otherwise noted. Catalyst and curing recommendations of the resin manufacturers were followed. Each laminate sample contained approximately 35 per cent reinforcing fiber by volume.

The ability of synthetic fibers to withstand exposure to different types of corrosive conditions is clearly reflected in their laminates. Tests conducted with these laminates have shown that they have excellent resistance to weathering. After exposure outdoors for more than a year, polyester resins reinforced with Orlon acrylic fiber and Dacron polyester fiber showed little or no change in strength or surface appearance, except for a slight yellowing attributed to the resin. By contrast, laminates reinforced with glass and cellulosic fibers deteriorated considerably in both appearance and strength. Degradation of these laminates was particularly pronounced where the surface resin had been removed by sanding to simulate the result of wear.

The effect of water on synthetic fiber laminates has been studied. The moisture absorption after twenty-four hour immersion at room temperature is shown in Figure 1. Laminates reinforced with Dacron, Orlon, nylon and glass fibers were generally comparable, all exhibiting a very low moisture pick-up. The cotton and rayon lamin-

*Registered Du Pont Trademarks.

Presented at the 13th SPE Technical Conference.

ates absorbed four to five times as much. Figure 2 shows the effect of continuous immersion in water at 50 degrees C on the tensile and impact strengths of laminates reinforced with Dacron, Orlon, and silane-treated glass mat. The synthetic fiber laminates were practically unaffected by these conditions. The glass laminates, although initially much stronger, lost strength at a relatively rapid rate throughout the 20 weeks of exposure.

Strong acids produced similar effects on these laminates. The results of exposure to 40 per cent sulfuric acid at 50 degrees C, and to 10 per cent hydrochloric acid at room temperature are presented in Figures 3 and 4, respectively. Sulfuric acid was particularly damaging to the glass laminates, which lost approximately 75 per cent of their strength after 20 weeks. The laminates reinforced with Orlon were unaffected by this exposure, and those reinforced with Dacron polyester fiber were only mildly degraded.

Both the high initial strength of glass laminates and the excellent durability of synthetic fiber laminates are frequently desired in an end-product. This can be accomplished by employing the synthetic fibers as a surface overlay to complement the glass fiber reinforcement. In one such application, a glass-reinforced polyester tank cover with a surface overlay of Dacron is still performing satisfactorily after 15 months on a pickling tank in a steel mill. This cover replaced rubber-lined steel which failed in the hot sulfuric acid environment after 12 months.

In another application, the acid resistance of Orlon acrylic fiber is combined with the strength of glass in a corrosion-resistant structural angle. This part, of reinforced epoxy resin, is exposed to an atmosphere of dilute sulfuric acid and hypochlorite bleach solution at temperatures of 50 to 90 degrees C. The aluminum angles previously used had to be replaced every six months. The plastic angles overlaid with Orlon have given three years service to date, and are expected to last for at least two more.

In still another operation, an epoxy resin filter frame reinforced entirely with Orlon has performed in 30 per

Figure 1. Moisture absorption of reinforced polyester resins.

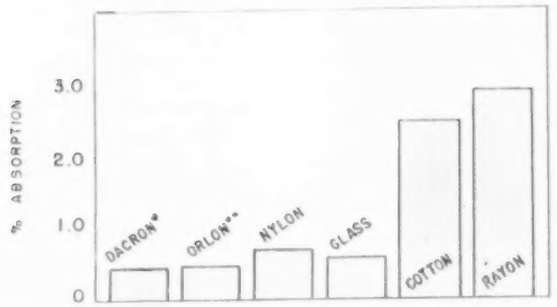


Figure 2. Corrosion resistance reinforced polyester resins.

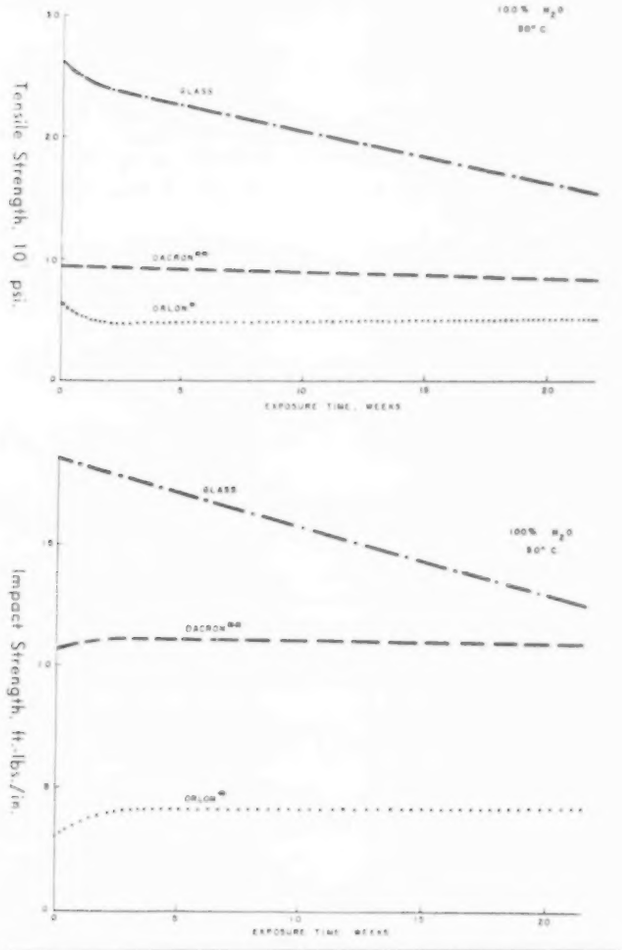
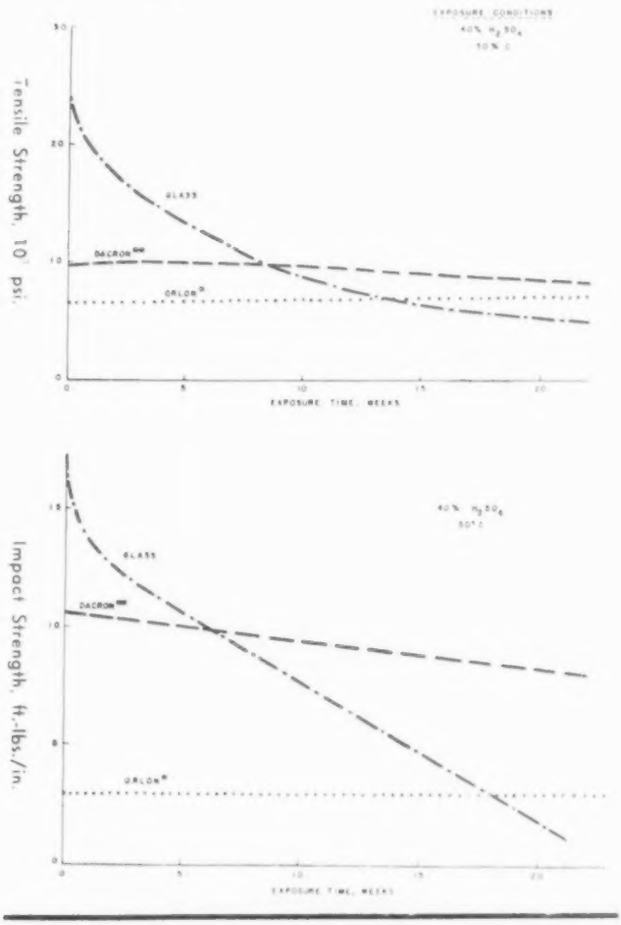


Figure 3. Corrosion resistance of reinforced polyester resins.



cent sulfuric acid at 50 degrees C for 15 months without evidence of deterioration. Previous frames made of wood-Monel combinations required repair after four months, and replacement after 12 months. A glass-reinforced epoxy resin frame, which was also tested, failed after two months.

Figure 4. Corrosion resistance of reinforced polyester resins.

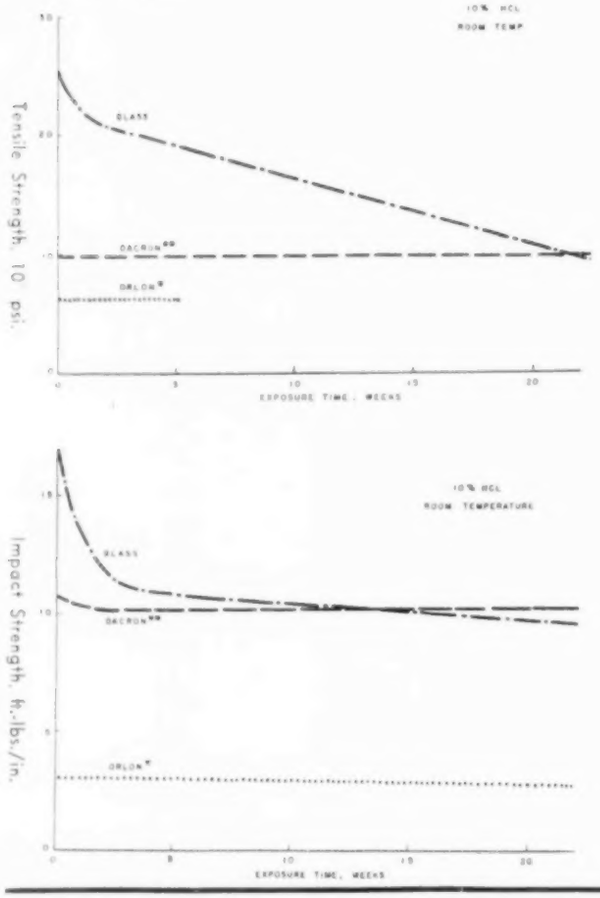
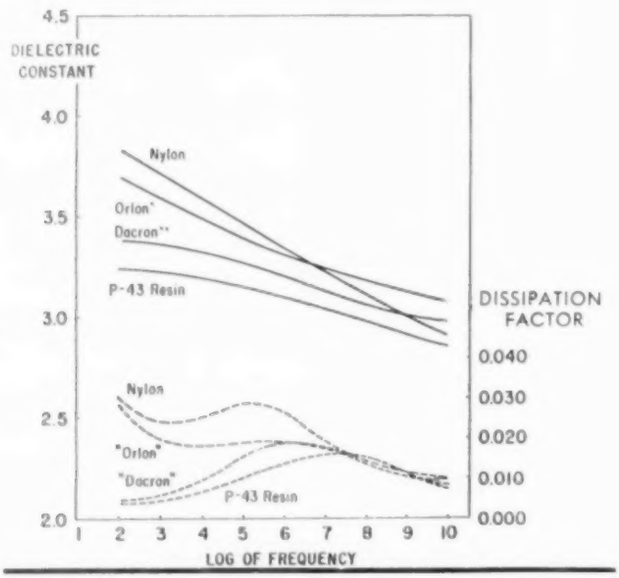


Figure 5. Dielectric properties of reinforced polyester resins.



These are a few of the cases where outstanding performance has been established. Similar reports have been received about other corrosion-resistant uses, such as trays, piping, ducts and tanks.

Synthetic fiber reinforced plastics also show promise in electrical components. Laminates containing nylon, Dacron polyester fiber, and Orlon acrylic fiber possess good impact strength, adequate stiffness and may be machined by the various methods commonly used by industry. Of primary importance, of course, are the electrical properties which these laminates exhibit.

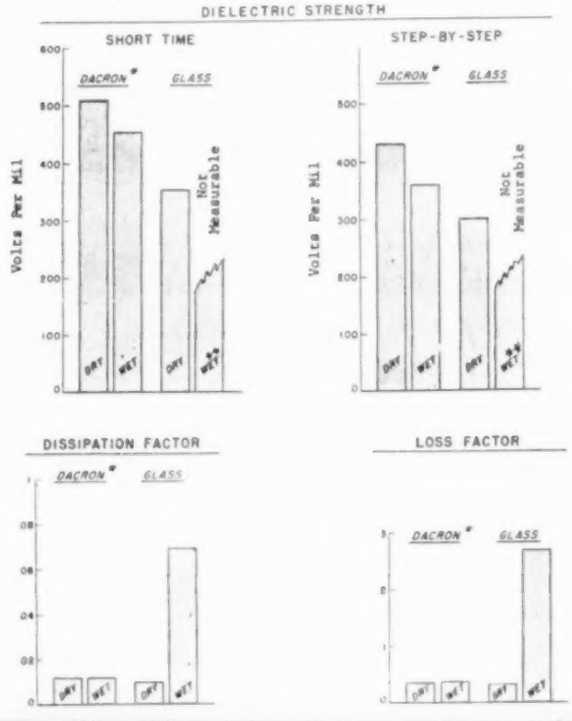
A determination of the dielectric constant and dissipation factor over a wide frequency range has shown desirably low values for laminates reinforced with nylon, Dacron, and Orlon (Figure 5). These properties are especially important in the selection of materials for high frequency applications. The laminate reinforced with Dacron closely matches the unreinforced polyester resin in these properties. Because of this similarity, consistent electrical performance can be expected regardless of variations in fiber content through the laminate.

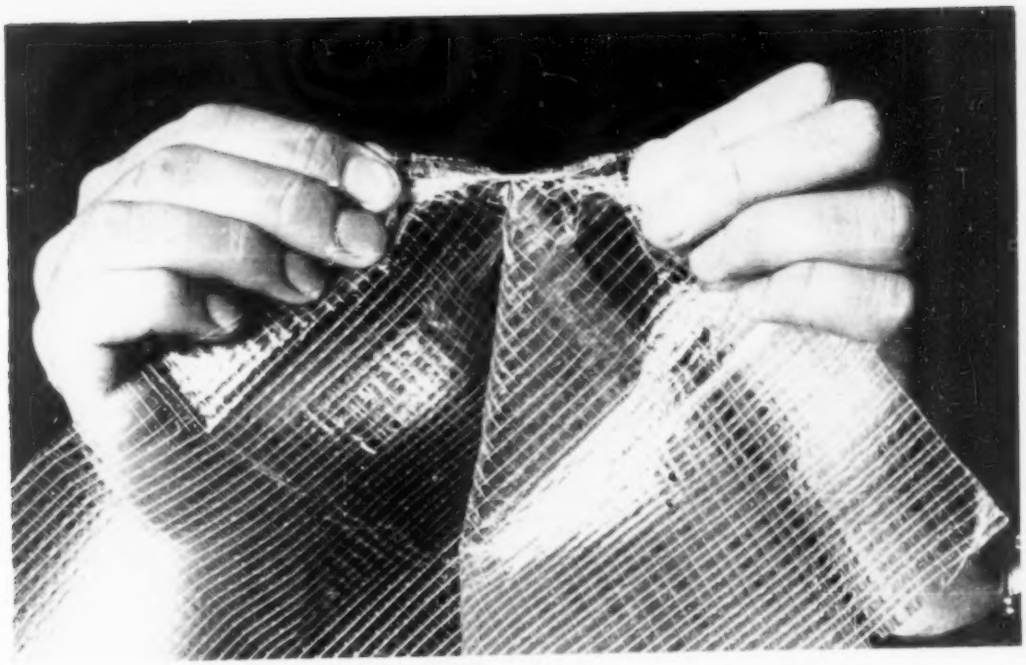
Undoubtedly one of the most important characteristics of synthetic fiber laminates for electrical uses is the stability of their electrical properties despite changes in humidity. In Figure 6 the dielectric strength, dissipation factor and loss factor of polyester resins reinforced with Dacron and glass are shown for both wet and dry conditions. When tested dry, the electrical properties of these two materials are similar. Moisture, however, produces a pronounced change in the properties of the glass laminate, while those of the laminate containing Dacron polyester fiber are relatively unaffected.

Measurement of insulation resistance under ASTM humidity-cycling conditions showed that polyester laminates reinforced with either Orlon acrylic fiber or Dacron maintained high resistance throughout a 29 day test. The results of this test are presented in the following Table.

(Please turn to page 65)

Figure 6. Dielectric properties of reinforced polyester resins.





Extreme Strength Reinforced Plastic Films

Johan Bjorksten

Bjorksten Research Laboratories
Madison, Wisconsin

EXTREME STRENGTH reinforced plastic film systems have been developed which are plastic films reinforced with slightly twisted Dacron or nylon yarn[1].

This fabric-film has been produced on a pilot plant scale since early 1955. Arrangements have now been completed with an Eastern manufacturer for large scale production.

This material is a non-woven, high strength material which is extremely tear resistant, with high tensile strength and high bursting strength per unit weight.

The present fabric-film can be made using almost any plastic film. A combination of films such as polyethylene with Mylar can be used. Other plastic films which are used include polyvinyl chloride, polyethylene and vinylidene chloride copolymerized with vinyl chloride. Polyethylene which is pigmented with carbon is combined with Mylar to give an excellent weather resistant film.

The films are reinforced with a slightly twisted multifilament Dacron or nylon yarn, this yarn being preferably 1100 denier. The reinforcing yarn is arranged into a grid of strands rectilinear, triangular or hexagonal in form. The rectilinear pattern is formed by cementing parallel strands on the two film sheets. The two sheets are then cemented together so that the threads on the individual sheets are in contact at right angles. A hexagonal pattern in the form of a net is unsatisfactory as the reinforcing yarn.

The adhesive used is a pressure sensitive adhesive of the rubber cement type, which allows the fibers to slip and pile up to form a rope. It also gives a flexible material.

Work on these systems originated under contract No. AF33(616)403 from the Wright-Patterson Air Force Development Center. The purpose of the contract was to develop a non-woven, high strength sheet material suitable for application in personnel parachutes. Polyester films were chosen for the original investigation since their properties looked promising except for their low tear resistance.

To improve their tear resistance, long, short and staple fibers were tried between these films using a rigid adhesive. The rigidity of the adhesive caused the fibers to be firmly anchored to the film. The fiber then acted as a cutting edge during tearing. Reinforcing fibers

[1] Trade Name "Griffolyn", Bjorksten Research Laboratories

This is a condensation of the paper presented at the 13th SPE Technical Conference.

This evening gown shows the ease of fabrication of reinforced film.

tried were glass fiber, nylon staple and nylon tow, Dacron thread, other natural and synthetic fibers and finally Dacron yarn.

In addition to a good reinforcing material, a flexible adhesive was needed. This had to allow the threads to slip when a tear started. These threads had to be able to pile up to form a barrier.

The fabric-film was first made on a "loomette" weaving loom, a square frame having pins embedded at equal intervals around the frame. The "loomette" is threaded by running the thread from a pin on one side of the frame to a pin opposite until the length and the width are threaded. While threading the loom, the thread was coated with the adhesive by passing it through a glass tube containing a sponge saturated with the adhesive solution. After the loom was threaded, the solvent spread on the thread was allowed to evaporate. Two sheets of plastic film were coated then with the same adhesive and the solvent allowed to evaporate.

The reinforcing thread on the "loomette" was then sandwiched between the tacky surfaces of the two plastic sheets. The threads were cut loose from the pins and the laminate was then pressed.

The fabric was subjected to low temperature in a freezing cabinet of —65°F. for several hours. No embrittlement nor loss of flexibility occurred.

The systems' tear resistance is shown by starting a tear in the reinforced material by cutting with scissors. The tear only travels a very short distance before it can not be torn any farther. This pulling action piles up the reinforcing fibers until a barrier has been formed against additional tearing.

Material Tested	Weight Per Sq. Yd. Oz.	Tensile Strength lb./in.	Bursting Strength psi	Tearing Strength lb.
30B-5	5.6	120	134	230
5-5	3.0	171	155	220
#10 Duck (14.7 oz/sq. yd.) plain, untreated	14.7			11
18.0 oz/sq. yd. vinyl coated duck (base canvas, 9.5 oz/sq. yd.)	18.0			11
58-5	3.5	155	130	

Key—30B-5—3MIL Black polyethylene—.5MIL MYLAR
5-5—A double layer of .5 MIL MYLAR
58-5 .5MIL aluminized MYLAR—.5 MIL MYLAR

The Mylar material having only slightly twisted multifilament Dacron yarn sandwiched therein is extremely resistant to failure by flexing or creasing.

Weatherometer tests have also been carried out on the polyethylene films and the vinyl films. These films became very brittle after exposure for 379 hours. The Mylar film became brittle after 473 hours.

(Please turn to page 63)

Protective suiting is another possibility for reinforced film.

Determination of the . . .

Flow Properties of Thermoplastic Melts

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. . . a review of methods and instruments useful for measuring the flow properties of extremely viscous fluids with particular reference being made to problems peculiar to thermoplastic melts. . .

ONE OF THE MAJOR problems in the design and operation of plastics processing equipment is to predict how a given plastic will deform or flow when subjected to a particular system of stresses applied over a particular period of time. This is a tremendously complicated problem and a general solution is probably not possible. However, this can be split into less complicated problems that are less difficult to study and that will yield information of value. One of these is the study of the steady flow behavior of the molten plastic under a given set of boundary conditions.

A number of instruments for measuring flow properties have already been reported and many more are now in various stages of development. Because of the unusual range of viscosities and because almost all measurements must be made at elevated temperatures some difficult problems arise in the design of viscometers for thermoplastic melts. At the present time it appears that there is no one "ideal" viscometer.

Classification of Flow Behavior

The basic flow properties of a fluid are specified by the **flow curve,** which is a plot of shear stress, τ, versus shear rate, γ, at constant temperature. If the flow curve is known, the steady flow behavior of the material can be calculated for a given set of boundary conditions.

It will be useful first to classify flow behavior and define some terms. The classification and definitions used here closely follow those of Metzner (1). It must be emphasized that all molten plastics will, in experiments conducted over short timescales, exhibit behavior which can be attributed to both elastic and viscous properties. If the timescale of the experiment is made small enough (small fractions of a second), the molten plastic will behave as an elastic solid. On the other hand, if the timescale is large (of the order of seconds or larger), the converse situation arises and steady flow occurs. In this discussion we are concerned only with steady flow, that is, with experiments whose time scales are very large.

The simplest type of flow curve, which is never observed for molten plastics, shows a **linear relationship** between shear stress and shear rate. The slope of the curve is the viscosity, which is a constant of the material. Fluids which exhibit linear flow relationship are called Newtonian fluids and all materials which deviate from the linear relationship are termed non-Newtonian.

It is useful to classify non-Newtonian liquids further. The first basis for sub-classification is the effect of time on the flow properties. Here reference is made to effects which are noticeable over an extended period of time, in contrast to those in which the elastic properties of the fluid alter the flow properties in short time-scale experiments. If a material is subjected to a constant shear rate and the shear stress remains constant with time, then the shear stress is a unique function of shear rate and the flow properties are time-independent. On the other hand, if the shear stress either increases or decreases with time, then the flow properties are time-dependent and a simple flow curve is no longer sufficient to characterize the material.

In the case of materials having time-dependent properties several types of behavior are observed. In some cases the changes which occur are reversible, while in otner cases they are irreversible. Materials which have reversible time-dependent properties are either thixotropic if the shear stress, at constant shear rate, decreases with time or rheopectic if the shear stress

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Presented at the 13th SPE Technical Conference.

increases with time (Figure 1). The molecular processes responsible for this behavior are quite complex and may vary from one system to another. Such behavior is caused by processes which take an appreciable period of time to reach equilibrium. For such materials the flow behavior depends not only on the shear rate and temperature but also on the extent to which the system is displaced from an equilibrium state. Some materials will exhibit irreversible time-dependent behavior caused by irreversible chemical or physical changes. Examples would include the curing of a thermosetting resin and the curing by solution of the solid phase of a plastisol.

Many non-Newtonian liquids, including most thermoplastic melts, do not exhibit time-dependent properties. Such materials when subjected to a specific shear rate at a given temperature will have a unique value for shear stress, regardless of the previous history of the sample, excluding slow changes such as degradation. Where the slope of the flow curve decreases as the shear rate increases, the material is called pseudoplastic, and where the slope increases, dilatant, as shown in Figure 2. The molecular processes responsible for dilatancy and pseudoplasticity are presumably related to those responsible for rheopectic and thixotropic behavior, the difference being the length of time required for an equilibrium state to be reached. Very short times are required for the former two and long times for the latter.

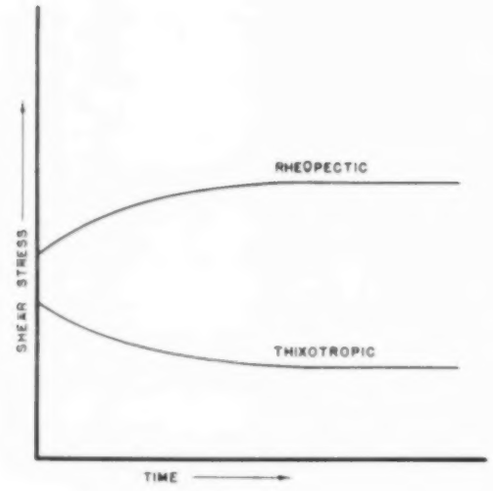


Figure 1: Behavior of time-dependent fluids.

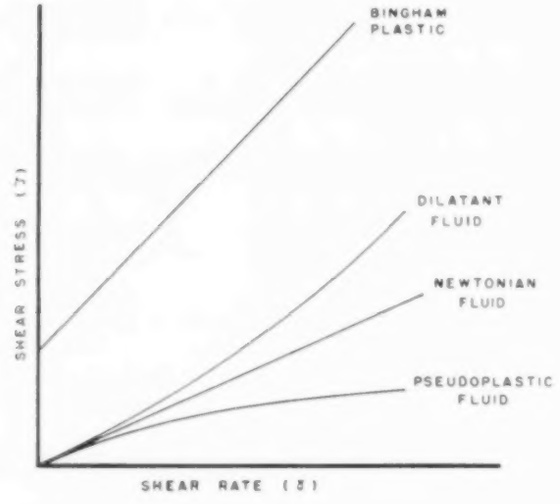


Figure 2. Flow curves.

Another subdivision of time-independent non-Newtonian liquids can be made on the basis of yield stress. Of those materials which do exhibit a yield stress, the simplest is the Bingham plastic, a material exhibiting combined yield stress and Newtonian flow. Other materials possessing a yield stress but having more complicated flow behavior can be postulated by combining various flow curves with a yield stress.

Review of Instruments

A wide variety of instruments has been used to study the flow behavior of fluids. The most useful and important types are extrusion and rotational viscometers. These instruments usually yield data from which true flow curves can be derived. Many other types of viscometers have been reported in the literature but most of them were designed specifically as control instruments, useful for comparative purposes but not for the determination of true flow curves. The following survey is limited to instruments which are capable of yielding data from which flow curves can be derived and which can be used with thermoplastic melts.

Extrusion Viscometers

The experimental data obtained with an extrusion viscometer gives a value for the flow rate of the fluid passing in laminar flow through a cylindrical extrusion tube and the pressure drop over the length of the tube. Several different types of extrusion viscometers have been designed and some are illustrated schematically in Figure 3.

The simplest apparatus consists of a gas tight reservoir into which an inert gas, such as nitrogen, is admitted under pressure and material forced out through an extrusion tube connected to the reservoir. One of the first instruments of this type was described by Bingham (2) in 1922. One of the most recent reports of the use of an instrument of this type was by Severs and Austen (3) for the determination of flow curves of PVC plastisols.

With many materials, instruments using gas pressure directly on the fluid are not satisfactory, since the possibility exists, particularly with materials having a high yield stress and high viscosity, that the gas will very quickly "channel" through the fluid and blow out the tube. One way to prevent this is to place a metal ball on top of the thermoplastic melt. In the gas actuated instrument described by Nason (4) an aluminum ball was used, while Karam, et. al. (5) describe a melt viscometer in which a tightly fitting steel ball is placed on top of the plastic melt.

Another approach to this problem is to use a cylinder and piston arrangement to force the material through the extrusion tube. Dillon and Johnston (6) in 1933 described an extrusion type instrument with a pneumatically operated piston. Another piston type instrument was developed by Atkinson and Nancarrow (7).

Schultz-Grunow and Weymann (8) describe an extrusion viscometer in which a very long extrusion tube is used and the pressure along the tube is measured with strain gauges attached to the outside of the tube.

When a fluid is forced through a cylindrical tube, the shear stress and shear rate range from a maximum at the tube wall to zero at the center. Regardless of the nature of the fluid, the shear **stress** across the tube is a linear function of radius, but the shear **rate** is linear with radius only for the special case of Newtonian flow. Therefore, it is essential that the flow curve be constructed using shear stresses and shear rates at the same place in the extrusion tube. The problem is to convert the measured quantities, extrusion rate and pressure drop, to shear stress and shear rate at some specific location in the tube. The most convenient location is the wall. The shear stress at the tube wall is given by the formula

(1)

$$\tau_w = \frac{R\,\Delta P}{2L}$$

where

τ_w = Shear stress at tube wall
R = Tube radius
L = Tube length
P = Pressure drop over tube

The shear rate at the wall is a more difficult quantity to determine from the experimental data. Rabinowitsch (9) first showed that if the extrusion rate is measured over a range of pressures and the slope of the extrusion rate-pressure drop curve evaluated, the shear rate at the wall can be calculated with the formula

(2)

$$\dot{\gamma}_w = \frac{1}{\pi R^3}\left[3Q + \Delta P\left(\frac{dQ}{d\Delta P}\right)\right]$$

where

γ_w = Shear rate at tube wall
Q = Extrusion rate
dQ/d(ΔP) = Slope of extrusion rate-pressure drop curve

Derivations of equation 2 are also presented by Mooney (10) and by Clark and Deutsch (11). Equation 2 is perfectly general in that it applies to all materials whose shear stress is a unique function, at a given temperature, of shear rate. Equation 2 can be made specific for various special cases, such as a pseudoplastic material obeying a power law. Equations applicable to this case are discussed by Reiner (12).

Many other factors enter into the interpretation of data from extrusion viscometers. Entrance effects, heat generation in the fluid, slippage at the wall, and effects caused by time-dependent flow properties must all be considered.

Entrance effects in extrusion viscometers may arise from several different causes. The first effect to be considered is caused by the disturbance in the flow pattern as the fluid, initially in the reservoir of large cross section, converges into the tube of small cross section. The convergence is an extremely complex viscous flow phenomenon. The converging flow absorbs energy and contributes to the total pressure drop in the instrument.

Energy is also absorbed when the fluid, essentially at rest in the reservoir, is accelerated to its tube velocity. The amount of energy used for this acceleration will usually be quite small compared to that dissipated in the extrusion tube unless the extrusion rate is high. If ΔP_a is the loss in pressure due to the acceleration of the fluid and ΔP is the pressure drop due to viscous flow in the extrusion tube, an **estimate** of the relative importance of this effect can be made with the formula

(3)

$$\frac{\Delta P_A}{\Delta P} = \frac{\rho Q}{16\pi\eta L}$$

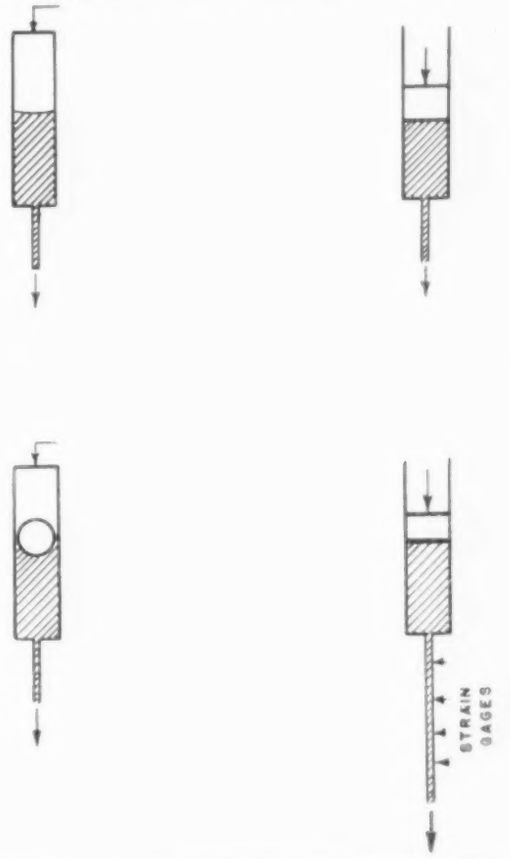
where

Q = Extrusion rate
ρ = Melt density
L = Length of extrusion tube
η = Apparent melt viscosity

Another effect which may occur at the entrance is due to the elastic behavior of many thermoplastic melts. As the melt flows into the entrance of the extrusion tube, the flow is unsteady and elastic stresses can be set up in the melt. As the melt enters the tube, the elastic stresses begin to relax. The magnitude of the stresses and the time required for stress relaxation to occur depend upon the nature of the material. In some cases these effects can be quite large and the energies involved will be appreciable. At the present time it is not possible to calculate these effects and they must be determined by experiment.

The contraction, kinetic energy, and elastic effects which have been discussed are best corrected for by experiment. One obvious method would be to make the tube so long that the entrance effects would become negligibly small in comparison to the viscous effects in the extrusion tube. A length to diameter ratio for the tube of about 100/1 are usually required. Another more positive method of eliminating entrance effects would be to use a series of extrusion tubes, each having a different length but the same diameters. For a given extrusion rate, a plot of ΔP

Figure 3. Extrusion Viscometers.



versus L would be made and the curve extrapolated to the point where the effect of L became negligible.

Analysis of extrusion viscometer data is based on an assumption of zero fluid velocity at the wall of the tube. In the case of pure thermoplastic melts this is usually a valid assumption since the material will usually "wet" the wall of the tube. If the material does not wet the wall of the tube, then it may slip or slide over the metal surface and the analysis of the data will be in error. With some materials slippage can be a severe problem and it may not be obvious to the experimenter that it is occurring. Slippage can be tested for experimentally by determining flow curves with extrusion tubes of different diameters. If the flow curves are not identical, but are dependent on diameter, then there is a good possibility that slippage exists. In such an experiment corrections may be made as described by Mooney **(10)**.

Another type of slippage also can occur in extrusion of suspensions which exhibit a yield stress. In this case the solid dispersion may break down in the region adjacent to the wall of the tube leading to a thin annular layer next to the wall which is much more fluid than the bulk of the material. Most of the flow will occur in this layer while the bulk of material will pass through the tube as a plug. Methods of detecting and correcting for this effect are discussed in detail by Reiner **(12)**.

The analysis of extrusion viscometer data is also based on the assumption of isothermal flow in the extrusion tube. Since extrusion viscometers are quite readily thermostated, even for high temperature work, the problem of non-isothermal conditions is not always appreciated. Assuming that the wall of the extrusion can be maintained at an absolutely uniform and constant temperature, severe heat effects can arise through heat generation by viscous shearing in the fluid itself. The rate of heat generation, per unit volume of fluid, is proportional to the viscosity and to the second power of the shear rate. Therefore, when high viscosity materials are extruded at high shear rates, the internal generation of heat can become a serious problem. If the material in the tube is non-uniform in temperature and the data are analyzed on the basis of the isothermal flow equations, the correct flow curves will obviously not be obtained.

Bird **(13)** has carried out a mathematical analysis of heat effects in extrusion viscometers. He has derived equations for special types of flow behavior giving the effect of viscous heat generation for the case where the walls of the tube are maintained at a constant temperature and also for the case where the walls are assumed to be perfectly insulated.

As a specific example of the use of his equations, he calculates the average temperature rise of a fluid in an extrusion viscometer in which the tube is 1.28 cm long and has a radius of 0.039 cm. He takes the case where the inlet temperature of the fluid is 190°C and uses physical constants corresponding to a typical molten polyethylene. The results of these calculations indicate that in this particular case heat generation will become a serious problem at shear stresses above about 10^6 dynes/cm^2.

Rotational Viscometers

Some of the various types of rotational viscometers are shown schematically in Figure 4. In all of these instruments one member rotates and the other is stationary; the fluid is sheared between the members. In some instruments the rotating member is driven by a motor. The measured quantities are the speed of rotation and the torque required either to maintain the motion of the rotating member or to restrain the stationary member. In other instruments the rotating member is driven by weights which impart a constant torque and the speed of rotation is measured.

In the concentric cylinder instruments, if the gap between the cylinders is extremely small, the motion approaches that of infinite parallel plates. In this limiting case the fluid in the gap is subjected to uniform shear and the shear rate and shear stress are calculated from the measured quantities with the formulas,

(4)

$$\tau = \frac{M}{2\pi R^2 L}$$

(5)

$$\dot{\gamma} = \frac{2\pi RN}{\delta}$$

where

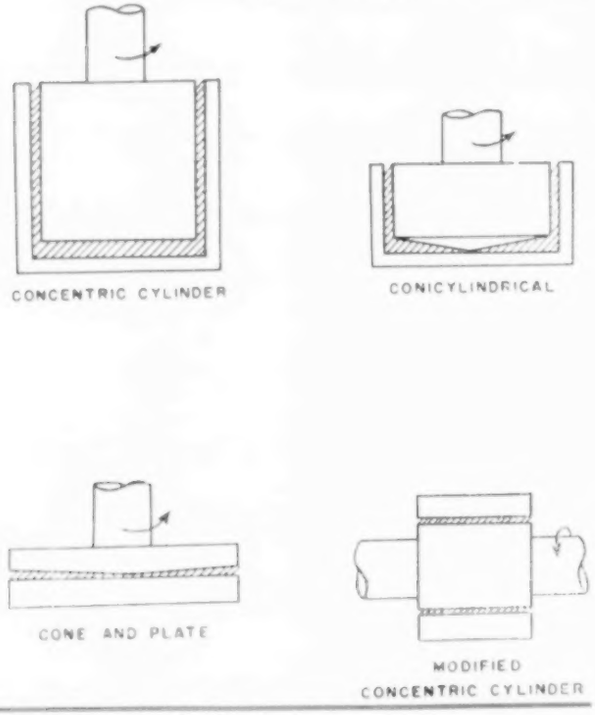
M = Torque
R = Radius
L = Height
N = Rotational Speed
δ = Clearance

In many instruments the clearance between the inner and outer cylinders is large enough so that the shear stress and shear rate vary across it. In this case the flow curve must be constructed with shear rates and shear stresses calculated for the same point in the apparatus. For Newtonian liquids it is a simple matter to calculate the shear stress and shear rate at any position in the gap. See, for example, Reiner **(12)**. When the fluid is non-Newtonian, however, the situation becomes considerably more complicated. In this case the best approach is to calculate the shear stress and shear rate at the wall of the inner cylinder. The stress at the inner cylinder is given by the formula

(6)

$$\tau_i = \frac{M}{2\pi R_i^2 L}$$

Figure 4. Rotational Viscometers.



where R_i = radius of inner cylinder

The shear rate at the wall of the inner cylinder can be calculated from the data using the formula derived by Krieger and Maron **(14)**.

(7)

$$\dot{\gamma}_i = \frac{4\pi N}{1-K}\left[1 + C_1\alpha + C_2\left(\alpha^2 + \frac{d\alpha}{d\ln M}\right)\right]$$

where

$K = D_i/D_o$

D_i = Diameter of inner cylinder

D_o = Diameter of outer cylinder

and

$$\alpha = \left[\frac{d\ln N}{d\ln M} - 1\right]$$

The instrument constants c_1 and c_2 are defined by the equations

$$C_1 = (1-K^2)\left(\frac{1}{2} - \frac{1}{3}\ln K\right)$$

$$C_2 = \left(\frac{K^2-1}{6}\right)\ln K$$

Equations 6 and 7 apply to all materials in which the shear stress is a unique function of shear rate.

The cone-and-plate instrument is particularly useful because of the direct and simple manner in which the measurements may be interpreted. In the cone-and-plate viscometer the entire sample is subjected to uniform shear, i.e., the shear rate and shear stress are constant at all points in the fluid if the edge effect is neglected. Measurements of rotational speed and torque are converted to shear stress and shear rate with the formulas

(8)

$$\dot{\gamma} = \frac{2\pi N}{\theta}$$

(9)

$$\tau = \frac{3M}{4\pi R^3}$$

where

θ = Conical Angle

R = Radius

An instrument which combines features of both the cone-and-plate and the concentric cylinder viscometers is the conicylindrical viscometer. The theory for this instrument was presented by Mooney and Ewart **(15)** in 1934. In this instrument the conical angle and the radial clearance are designed so the shear rate in the conical section is equal to the average shear rate in the annular section. In this way the troublesome end effects associated with concentric cylinder viscometers are eliminated.

Another approach to the problem of end effects in concentric cylinder viscometers is to make the outer member a hollow cylinder open on both ends. If the radial clearance between the cylinders is small and the viscosity of the fluid is high, the fluid will remain in position. An instrument with a radial clearance of approximately 0.006 inches, recently described by Merrill **(16)**, is of this general design.

Rotational instruments which are potentially useful for thermoplastic melts have been described by Traxler **(17)**, Buchdahl **(18)**, Dexter **(19)**, Barber **(20)**, Markovitz **(21)**, McKennell **(22)**, and Philippoff and Gaskins **(23)**.

Traxler's instrument was designed to measure the flow properties of high viscosity asphalts. The cup of the instrument is closed at both ends and the top and bottom of the bob are both conical so that corrections for end effects may be made.

A concentric cylinder viscometer of the Stormer type has been used by Buchdahl **(18)** to determine flow curves for polystyrene at 200°C over a range of shear rates from about 0.1 to 10 sec^{-1}. The end of the rotating cylinder was shaped into a cone, but the cone was not designed so that the rate of shear at the conical and cylindrical surfaces are the same. The shear against the cone in this instrument can be a significant part of the total shear.

Dexter **(19)** has determined flow curves for polyethylene melts at temperatures from 130 to 210°C and over a range of shear rates from 0.1 to 100 sec^{-1}. His instrument is essentially the same as Buchdahl's instrument except that the radial clearance was about 0.16 cm.

Barber **(20)** described a concentric cylinder viscometer designed to determine the flow properties of lubricating oils at high shear rates. The instrument is particularly interesting because of the extremely small radial clearance (0.00005 inch) between the cylinders. With this instrument shear rates up to 10^6 sec^{-1} were obtained.

Markovitz **(21)** has described a weight driven cone-and-plate viscometer of wide range which employs a slightly truncated cone. The use of a truncated cone makes it comparatively easy to position the two elements, and introduces only a very small error. Shear rates from 0.0002 to 9000 sec^{-1} and viscosities of from 1 to 50,000 poises have been measured with this instrument.

McKennell **(22)** has described a cone-and-plate viscometer which is commercially available. The instrument is operable over a wide range of shear rates and employs a cone with an extremely small angle so that the thickness of the fluid film at the periphery of the cone is only about 0.005 inch.

Philippoff and Gaskins **(23)** recently reported the results of an extensive investigation of the flow properties of molten polyethylene and plasticized polyvinylbutyral. Two conicylindrical instruments were used to cover a wide range of variables. Low shear rate measurements (about

Figure 5. Miscellaneous Viscometers.

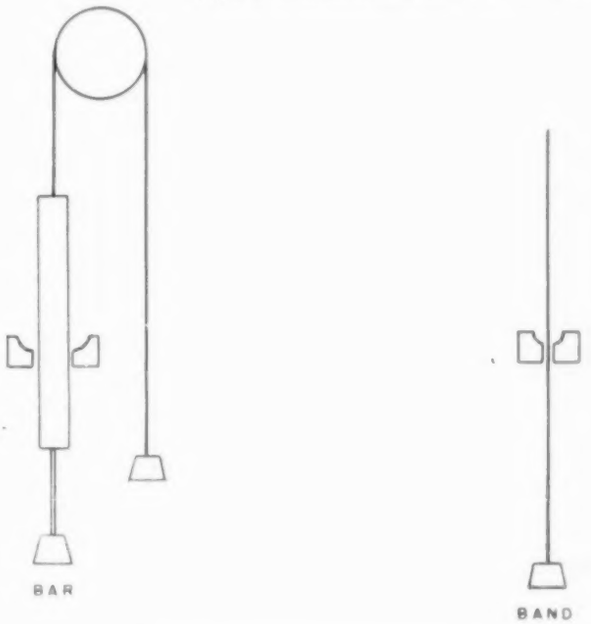


TABLE 1

Results of Measurements on Thermoplastic Melts.

Material	Temperature Range	Type of Instrument	Range of Shear Rates	Reference
Polystyrene	135-220°C	Concentric Cylinder Viscometer	.04-25 sec^{-1}	Buchdahl (18)
Polyethylene	110-190°C	Parallel Plate Plastometer	Newtonian Region	Dienes and Klemm (26)
Polyethylene	130-210°C	Concentric Cylinder Viscometer		Dexter (19)
Polystyrene	165-250°C	Extrusion Viscometer		Spencer and Dillon (27)
Polyethylene	125-250°C	Conicylindrical Viscometer	10^{-3}-10^{-1} sec^{-1}	Phillippaff and Gaskins (23)
Vinyl Chloride Acetate	130-170°C	Parallel Plate Plastometer	Newtonian Region	Dienes (28)

5×10^{-5} to about 10^{-1} sec^{-1}) were made using an instrument having a gap of about 0.19 in., while high shear rate measurements (about 10^{1} to 10^{3} sec^{-1}) were made in an instrument having a gap of about 0.0035 inch. The temperature range covered was from about 110 to 250°C.

Miscellaneous Viscometers

Two rather special instruments, the band viscometer (24) and the bar viscometer (25), are shown schematically in Figure 5. These instruments are of interest because the shearing action to which the fluid is subjected approximates that of shear between infinite parallel plates. Although neither of these instruments has been used for measuring the flow properties of molten thermoplastics, it is possible that with suitable design changes they could be adopted for such use.

The parallel plate plastometer is another rather well known instrument. It consists of two circular parallel plates, the lower plate being fixed in position and the upper plate. As the plate separation decreases, the sample is placed between the plates and a force is applied to the upper plate. As the plate separation decreases the sample undergoes viscous flow and is squeezed out. With a constant force applied to the upper plate, the experimental data consist of the plate separation and time. From these it is easy to calculate the viscosity of Newtonian materials. Dienes and Klemm **(26)** have discussed the theory of viscous flow in this instrument and its application to thermoplastic melts. It should be pointed out that with thermoplastic melts the instrument is useful only at extremely low shear rates where the melt approximates Newtonian behavior.

Results of Measurements on Thermoplastic Melts

A limited number of investigations of flow properties of thermoplastic melts have been reported in the literature. Table 1 summarizes the results of some of these investigations.

Discussion

Many of the problems which arise in the design of viscometers to be used to measure the flow properties of thermoplastic melts are difficult to overcome. The two primary reasons for these problems are, first, the unusually high viscosities of the materials involved (up to 10^{6} poises and higher for some materials) and, second, the fact that almost all measurements must be made at elevated temperatures (100°C to about 300°C.)

At the present time it appears that there is no one "ideal" viscometer for thermoplastic melts. Three factors, mechanical design, interpretation of data, and the range of the instrument, must be considered in the evaluation of any particular instrument.

Mechanical Design

Loading and unloading the sample presents a serious mechanical problem with many viscometers. At room temperature the sample is a solid and even at the test temperature the viscosity of most thermoplastics will be so high that it is impossible to pour the material. In the case of extrusion viscometers this problem is largely overcome, since the plastic may be placed in the chamber of the instrument as a solid and then brought up to temperature before it is forced into the extrusion tube. In cone-and-plate instruments the obvious method of loading is to mold the sample into a shape approximately the same as the space between the cone and the plate. The molded sample can then be placed in the instrument as a solid and brought up to the desired test temperature. Removing the sample after the test may prove to be more difficult, since the plastic may adhere tenaciously to the metal parts of the apparatus. Scraping the sample loose may, in time, tend to damage the plates, although this appears to be the only method available.

In the case of concentric cylinder viscometers, loading is even more difficult. Since very small radial clearances are necessary in instruments of this type, it appears that the only practical method of loading is to extrude the molten material, under pressure, into the annular space. Suitable apparatus would have to be provided with the instrument for this purpose. Removing the sample is an even more difficult problem than in the cone and plate instruments. Presumably the inner cylinder could be pulled out and the sample scraped off the surfaces. A better approach might be to displace the molten plastic from the annular space with a high temperature grease.

High temperature operation presents other design problems. Extrusion type instruments are, of course, relatively easy to thermostat. The reservoir and the extrusion tube can be controlled to a relatively close temperature with electric heating elements, or the entire apparatus can be jacketed for the circulation of a high temperature heat transfer fluid. Rotational instruments present a more difficult problem. In this case jacketing the entire instrument is very difficult and electric heating elements offer the most likely means of temperature control. Elements must be placed on both the stationary and rotating members which means that suitable slip rings must be provided for the electrical connections on the rotating member.

Interpretation of Data

If the objective of the flow measurements is to obtain

the most generally useful data, then the experimental results must be capable of being converted to flow curves. In other words, the results of the test should reflect only the nature of the material being tested and should not be a complex function of material and instrument constants.

With many types of materials, flow curves can be determined with both rotational and extrusion viscometers. It appears that a properly designed rotational instrument offers several advantages over an extrusion instrument.

The problems caused by the so-called entrance effects in extrusion viscometers have already been discussed. Since almost all thermoplastic melts have rather pronounced elastic properties, extremely long tubes must be used to make the elastic effects negligibly small. Alternately, experiments must be performed with several different tubes. This, of course, means that the amount of work involved in the determination can become quite large. With rotational instruments such problems are eliminated. At the instant a rotational instrument is started, the elastic properties of the melt should be noticeable, but by maintaining a constant speed or constant torque an equilibrium condition will soon be reached and steady flow obtained.

Another advantage of rotational instruments is that useful information can be obtained with materials whose flow properties are time-dependent. Reversible changes which occur in thixotropic or rheopectic fluids can be readily detected in a rotational viscometer. The analysis or even the detection of these effects in an extrusion type viscometer would involve a rather elaborate experimental program. This is due to the nature of flow through a tube. Since the fluid velocity varies across the radius of the tube, the residence time of each fluid element passing through the tube is different, the fluid near the center having a short residence and the fluid near the walls having a long residence in the tube. Consequently, from the viewpoint of the time history of the fluid, the experimental measurements are being made on an extremely heterogeneous sample. This problem does not exist in a rotational instrument since the measurements are made on a sample which remains in the instrument and which has a uniform history.

In the case of those materials whose flow properties undergo irreversible changes due to heat or the shear stresses, a rotational instrument offers the possibility of yielding useful information, since it is possible to measure continuously the changes in the fluidity of the material with time. For the reasons mentioned above, it would be difficult if not impossible to obtain similar information using an extrusion viscometer.

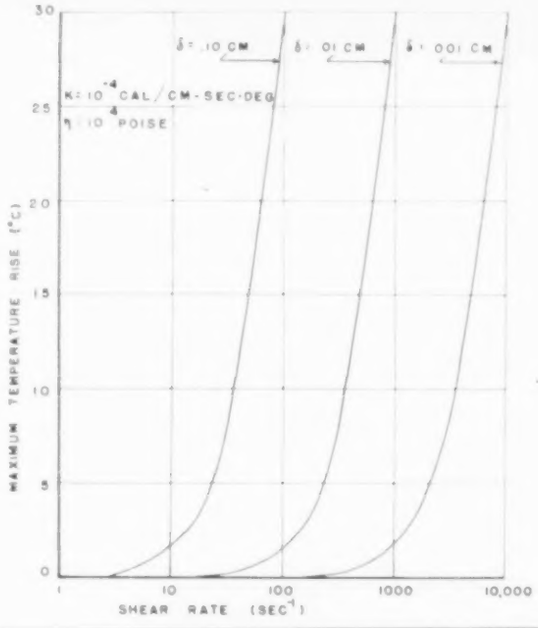
It should be pointed out that these advantages can be realized only if the rotational instrument is designed so that the sample is subjected to a uniform rate of shear. The cone-and-plate viscometers do so only in the limiting case when the radial clearance approaches zero. However, if the radial clearance is of the order of one per cent or less of the diameter, the requirement of uniform shear is met to a close approximation.

Operating Range:

In the various operations of thermoplastic processing the molten material may be subjected to a wide range of shear rates. Consequently it is desirable that the flow curve be measured over a range of shear rates of 1 to 1000 sec^{-1}. Although an operating range of this width imposes certain mechanical problems, these problems have been overcome by the designers of many of the instruments discussed in this paper.

As has been mentioned before, one of the major problems connected with the design of an instrument to work, in particular, at high rates of shear is that of internal heat generation in the fluid.

Figure 6. Effect of heat generation in concentric cylinder viscometer.



For the case of concentric cylinder viscometers, if the radial clearance is small so that the action approaches that of infinite parallel plates, then the effects of heat generation can be calculated. For example, an order-of-magnitude estimate of the maximum temperature difference existing in the fluid in a concentric cylinder viscometer can be made with the equation (10)

(10)

$$\Delta T = \frac{J\eta N^2 \pi^2 D^2}{8K}$$

where

T = Temperature difference in fluid (°C)
J = Conversion factor (2.39 x 10^{-8}-cal/erg)
η = Apparent viscosity (poise)
D = Diameter of cylinder (cm)
K = Thermal conductivity of fluid (cal/cm-sec-deg)
N = Rotational speed (rps)

Equation 10 assumes that both surfaces are at a constant temperature and that the viscosity is independent of temperature. Colwell (29) has developed more exact equations in which the temperature dependency of viscosity is considered.

The shear rate in a concentric cylinder viscometer is given by the equation (11)

(11)

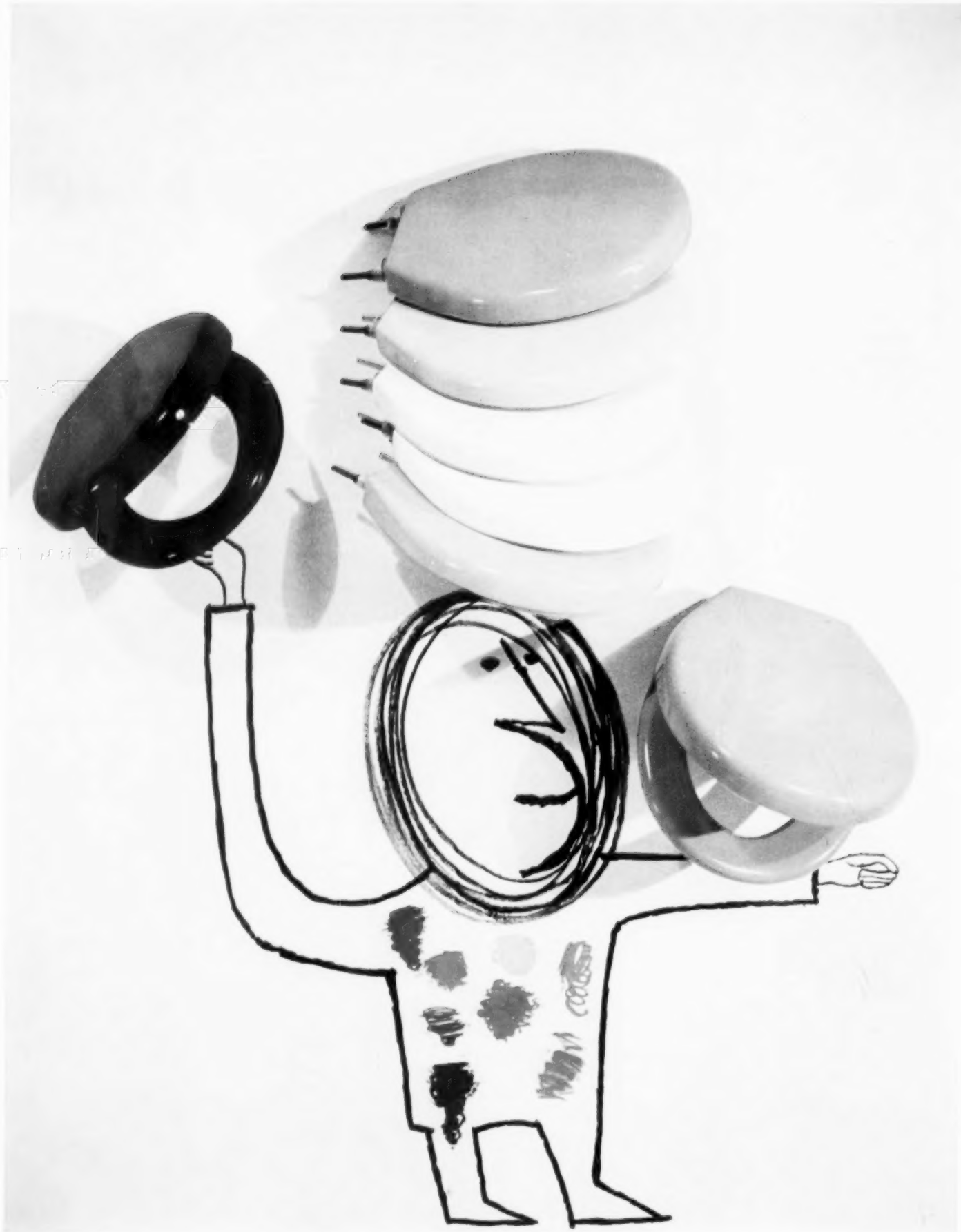
$$\dot{\gamma} = \frac{\pi D N}{\delta}$$

where

γ = Shear rate (sec^{-1})
D = Diameter of cylinder (cm)
S = Radial clearance (cm)
N = Rotational speed (rps)

Comparison of equations 10 and 11 shows that to obtain high shear rates with small temperature rises in concentric cylinder viscometers low rotational speeds should

(Please turn to page 64)



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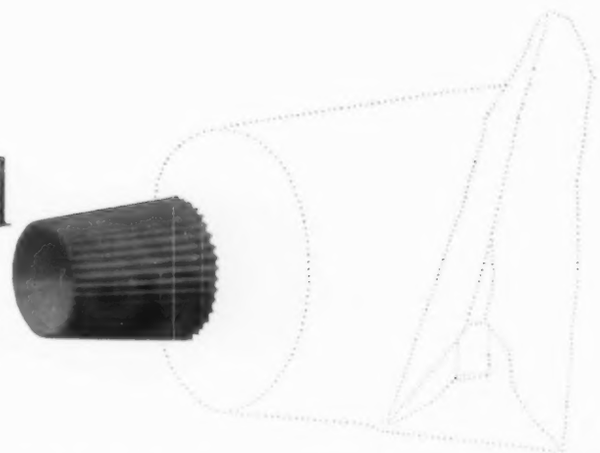
# of toilet seats and toothpaste caps...



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Measurement of the Birefringence of Oriented Plastic Sheeting

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The orientation of plastic materials by stretching, drawing, rolling, extrusion or other processes is a phenomenon which the reader has probably encountered. As a kind of side effect, the orientation retained by the material produces an optical anisotropy or birefringence. The birefringence may be used as an index of the amount of orientation.

If the manufacturing process produces in the material a uniaxial orientation, the measurement of the consequent birefringence is usually a simple problem. However, if the material is compressed or if it is stretched in two or more directions, a biaxial orientation results, and the measurement of the birefringence becomes more complex. It is this last problem which is considered in the present paper.

The case of biaxial stretching will be described in detail, as other cases in which more complicated systems of planar stresses are applied, may be reduced to this case. In Figure 1 the arrows indicate the two stretching directions. In general, the amounts of stretch in the two directions will not be precisely equal to each other. As a result, the sheet must be characterized by three indices of refraction, one, denoted by α, for light having its electric vector vibrating in the direction of the X-axis, and similarly, β and γ, the indices for the Y and Z directions. The difference between a pair of the indices is called the birefringence. Hence, there will be three characteristic birefringence values, $\beta-\alpha$ $\gamma-\beta$, and $\gamma-\alpha$.

If plane polarized light falls at normal incidence upon the sheet shown in Figure 1, it will be broken into two waves, one vibrating in the X-direction with an index of refraction α, and one vibrating in the Y-direction with an index of refraction β. Upon emerging from the far side of the sheet the two waves will be out of phase. If white light is used, the phase difference will be one wave length for some portion of the spectrum. The corresponding color will be removed, and the sheet, viewed between crossed polaroids, will appear tinted with the complementary color. To measure the birefringence causing the phenomenon, the usual technique employs a compensating material, having a birefringence opposite in sign to that of the specimen. A quartz wedge may be inserted in the path of the light beam and its position adjusted until the phase difference which it introduces is equal and opposite to that of the specimen. By calibration of the quartz wedge, the birefringence of the specimen may be computed.

The birefringence measured at normal incidence, $\beta-\alpha$, is a measure of the difference in the two amounts of stretch imposed upon the material. However, it gives no indication of the magnitude of the individual percentages of stretch. To measure $\gamma-\alpha$ and $\gamma-\beta$, the corresponding birefringence values, one may cut sections from the sheet with their faces parallel to the XZ and YZ planes, respectively. However, this method is obviously of limited utility. It is the purpose of this paper to describe two procedures for computing the birefringence of any section without cutting the sheet.

Both methods utilize the oblique incidence of polarized light upon the sample. This procedure is indicated in Figure 1, where the light beam is shown traversing the sheet at the angle r to the sheet normal. The problem consists of relating the birefringence measured for the transmitted beam at some arbitrary angle of incidence to that which would be measured if the light beam were parallel to the surface of sheet. If the incident beam is confined to the XZ plane, a position of the sheet will be found where the combined index arising from γ and α will be exactly equal to the intermediate index β. In this position the sheet will show no birefringence, as the index of refraction is the same for all directions of vibration of the light wave. Between crossed polarizers, the sheet will appear black. There will be two such positions for each

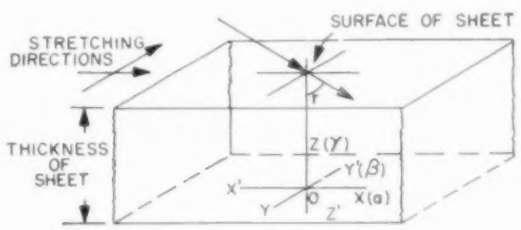

Figure 1. Biaxial Stretching and Birefringence.

Presented at the First Annual Technical Forum of the Baltimore-Washington Section of SPE.

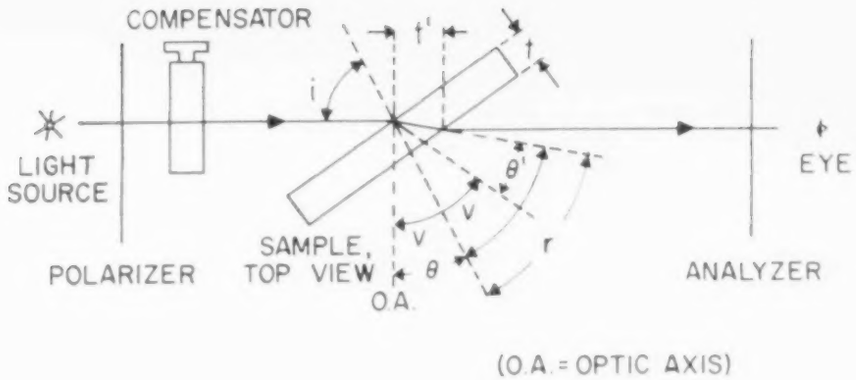

Figure. 2. Oblique Incidence of Parallel Light.

sheet, one on each side of the position for normal incidence. The direction of the light beam in each case is called the optic axis.

The procedures to be described each consists of two parts. The first step is comprised of finding the optic axes and noting their positions. The second step consists of viewing the sheet at some other angle of incidence and directly measuring the birefringence at this angle. The following equations[1] are then used to compute the desired birefringence values from the measurements.

$$\gamma' - \alpha' = (\gamma - \alpha) \sin\theta \sin\theta' \quad \ldots (1)$$

$$\sin^2 V = \frac{\beta - \alpha}{\gamma - \alpha} \quad \ldots (2)$$

$$\cos^2 V = \frac{\gamma - \beta}{\gamma - \alpha} \quad \ldots (3)$$

The second and third equations are corollaries to the first, which may be used for the solution of any case. The quantity $(\gamma' - \alpha')$ stands for the birefringence of any section. In the present application, it is specifically the measured birefringence at the arbitrary angle of incidence. The quantity $(\gamma - \alpha)$ is the birefringence to be computed. The angles θ and θ' are the angles between the optic axes and the direction of the light beam during the measurement at the arbitrary angle of incidence. The angle V in Equations (2) and (3) is the optic angle, the angle between an optic axis and the normal to the sheet.

Method of Determination

One method for determining the necessary quantities consists of placing the sheet in a parallel beam of polarized light and then directly measuring the desired quantities. This procedure is illustrated in Figure 2. Here the optic axes, found by tilting the sheet to the positions of zero birefringence, are already indicated. The sheet has been tilted to an angle **i** with the incidence beam. Because of refraction, the beam actually traverses the specimen at an angle **r**. It is seen that here the angles θ and θ' are the sum and difference of **V** and **r**. The quartz compensator is used to measure the phase difference introduced at the angle **r**; the phase difference per unit thickness gives the birefringence $(\gamma' - \alpha')$. All the quantities needed for computing $(\gamma - \alpha)$ from Equation (1) have then been determined. To compute $(\gamma - \beta)$ Equation (3) may be used.

The above procedure may be awkward for the inspection of large parts or continuous sheets. An alternative procedure is to place the example in a beam of convergent polarized light. A suitable instrument[2] is shown in Figure 3. The light source, L, should be a strong one, as the figure to be observed is rather weak. A water cell, W, may be used to protect the apparatus from the heat of the lamp. A polarizer P and an analyzer A are needed; circular polarizers are more convenient than plane polarizers. The lens, C, is a strongly converging lens; the substage condensing lens of a microscope is suitable. The sample is inserted in the beam after the lens. A screen is needed for viewing the figure obtained. In this apparatus, called a conoscope, polarized light falls on the sheet over a continuous range of angle of incidence. On the screen is seen a magnified image of the so-called interference figure of the sheet. The figure obtained for a polyester film is shown in title figure. The two "pupils" of the "eyes" are the points of emergence of the optic axes. The rainbow-hued rings and lemniscates seen in white light give a kind of panoramic view of the coloration of the sheet which would be seen if the sheet were tilted to the corresponding angle in a parallel beam of polarized light.

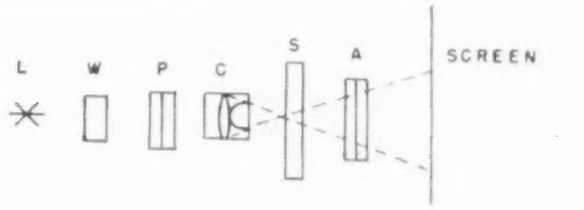

Figure 3. The Conoscope.

Qualitative Information

Certain qualitative information may be gained by inspection of the figure. The line joining the optic axes is the direction of greatest stretch. The transverse direction is the direction of least stretch. The separation of the optic axes is a measure of the relative magnitudes of the two amounts of stretch (see Equation 3). The density of the pattern is an indication of the magnitude of the birefringence. Local irregularities are clearly shown. One such irregularity is visible in the central portion of the largest ring in the title page photo which is the interference figure of a polyester film.

The quantitative determination of birefringence from an interference figure involves the conversion of distances on the screen to angles. By consideration of the geometry of the apparatus, the following relationship may be derived

$$c = (a + d)\, n \sin r\, (1 - n^2 \sin^2 r)^{-1/2} + b \tan r \quad \ldots (4)$$

where **c** is a distance measured on the screen from the center of the pattern to the point in question, **a** is the dis-

[1] The derivation of these equations may be found in textbooks of optical crystallography, such as "A. Johannsen, "Manual of Petrographic Methods" (McGraw-Hill Book Co., N.Y., N.Y., 1914)

[2] The use of similar apparatus for the demonstration of the characteristics of crystals is described by H. E. Buckley, Nature **143**, 801 (1939)

tance from the focus of the lens to the sample, **d** is the distance from the opposite sample face to the screen, **n** is the average index of refraction of the material, **r** is the angle to be determined, and **b** is the sample thickness. A tabulation or a graph of **c** for integral values of **r** may be used for solution of Equation (4). In Figure 4 is shown a plot of values for n = 1.50. Dimensions may be removed from the equation by dividing by (a + d), or by **a** alone if the screen is contiguous with the sample. The equation in Figure 4 is given in the latter form. If the thickness of the screen or the analyzer is significant with respect to the overall dimensions of the apparatus, corrections for refraction of the beam in them should be added.

Thickness Variation

Two features of Equation (4) are of interest. The solution is relatively insensitive to the thickness of the sample. Variations in thickness may be ignored for practical purposes, as long as they remain small with respect to the overall dimensions of the apparatus. Furthermore, if the relative positions of the lens and the screen remain fixed, so that (a + d) is a constant, the position of the sample in the apparatus does not affect the solution.

Once the optic angle has been determined by means of Equation (4), the birefringence at some other angle must be evaluated. Between the successive red and blue rings of the interference figure there appears a narrow purple line. This hue represents a phase difference of an integral number of wavelengths for the average wavelength of white light. The exact number of wavelengths phase difference may be determined by counting the number of purple rings, beginning with zero phase difference at the nearest optic axis. The angle of incidence corresponding to the given purple fringe may be found by measuring the distance from the fringe to the center of the interference figure, and then solving Equation (4) for the angle. With the three quantities, the optic angle and the birefringence at another angle, Equation (1) may be solved for the birefringence parallel to the surface of the sheet.

Accuracy of Measurements

The accuracy of the birefringence computed by the methods outlined above will depend on several factors. The quartz compensator is a sensitive instrument, but it must be used to its best advantage to attain high accuracy. The experimental measurements should be so made that the compensator measures a phase difference of the order of one wavelength minimum. If this condition is fulfilled, the error contributed by the compensator will be 1% or less. The measurement of the thickness of the sample should not ordinarily introduce significant error. The crucial measurement is the measurement of angles. For a typical sample of polymethyl methacrylate, a standard deviation of 2° in angle measurements results in a standard deviation of 5% in the birefringence determination. A standard deviation of 1° causes a standard deviation of about 2% in birefringence. For the same sample in a conoscope, measurements on the screen to 0.1 inch will give an expected error of 5% in the birefringence. The use of a travelling microscope should appreciably improve this accuracy.

A few comments on the usefulness of a birefringence determination are in order. The relationship of the birefringence to the amount of stretch must, of course, be determined empirically. For an amorphous high polymeric material, the relationship should be simple. In Figure 5, the birefringence of a series of polymethyl methacrylate

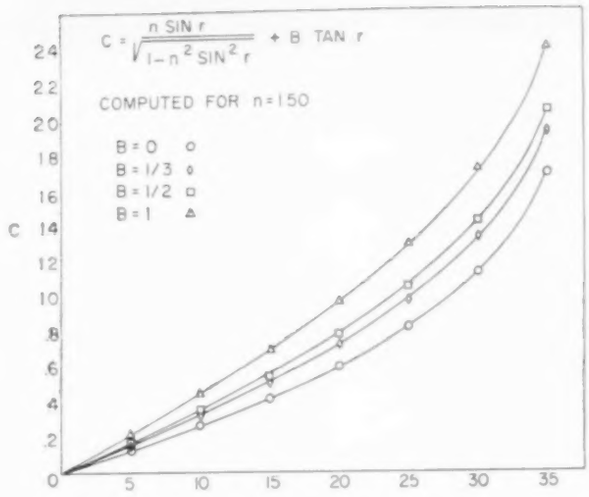

Figure 4. Solution of the Conoscope Equation.

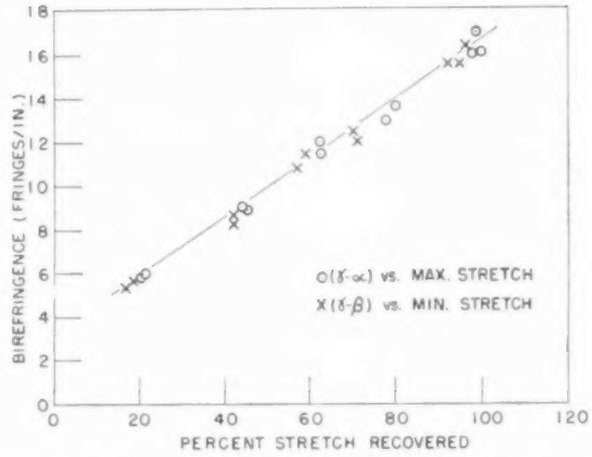

Figure 5. Birefringence of Stretched Polymethyl Methacrylate.

specimens is plotted against the percent stretch recovered when the specimens were allowed to relax without constraint at the stretching temperature. Once such a curve has been established the birefringence may be used as a measure of the amount of stretch, and also, as an index of other properties dependent upon the amount of stretch. If a polymeric material is partially crystalline, the interpretation of the birefringence becomes more complex. However, it may still be related empirically to particular manufacturing processes.

It is difficult to foresee all possible obstacles which may be encountered in the application of these methods to a variety of materials. However, a few possible difficulties may be pointed out. If the birefringence is very low or if the specimen is a very thin film, the accuracy of the birefringence measurement will suffer. If the optic angle is so high as to be out of the field of view, the birefringence must be found by solving simultaneous equations, a process which appears too cumbersome for routine measurements. It may also happen that the material may be so non-uniform that satisfactory measurements cannot be made. These difficulties are probably rare ones, however. It is expected that the methods should be suitable for a wide variety of materials. ★ ★

Mold Making by Electroforming

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. . . in these days of high mold costs and the increasing complexity of molded plastic parts, it is of major importance that every plastics engineer or technician understand and be able to evaluate any new process that may help to solve the difficult problems posed by molds not readily handled by routine mold making methods . . .

ONE OF THE MOST recent of new developments is the electroforming process of making plastics molds. Like many other special techniques, this process made rapid development strides during the war, and has found many applications in the production of both civilian and military items. Radar wave guides, ordnance shell components, fountain pen and razor parts, and phonograph record masters are only a few of the fields in which electroforming has proved advantageous.

In addition to making dies and molds for plastics, electroforming can be used for the production of metal parts, especially those of tubular, conical, or cup-like shape, more economically than by deep-drawing or other operations involving more than a simple swedging or stamping. By forming the part directly to the desired shape, secondary operations, such as punching, milling, and annealing, are eliminated.

The Electroforming Process

The electroforming process uses the simple principles and methods of electroplating. Whereas the latter method is concerned mainly with the production of attractive surface finishes or corrosion-resistant exterior coatings, electroforming involves the electrodeposition of a relatively thick layer of metal on a master mandrel and the subsequent removal of the plated shell from the mandrel so that a self-supporting part or formed article, not a mere coating, is produced.

A fairly large number of metals can be electroformed, the most common being nickel, copper, iron, and silver. Other metals which may be electroformed include lead, tin, cadmium, zinc, cobalt, indium, and chromium. Nickel is the preferred metal for making plastics molding cavities because of its hardness, resistance to tarnishing and rapid rate of deposition.

By using a Watts bath at 150 F., with modified operation techniques, and a current density between 200 and 250 amperes per square foot, we can plate nickel at a thickness rate of 0.010 inch per hour. Actually, a plating rate of at least twice this speed is possible, but is used only for forming molds or pieces in which only the internal surfaces next to the mandrel are critical. However, general forming at a thickness rate of more than 0.010 inch per hour is unsuccessful with economically practicable bath agitation because the external surfaces tend to develop ripples and other irregularities.

A master mandrel is the primary requirement for the production of cavities for plastics. This mandrel may be made of a number of materials. Where a large number of cavities is required, this mandrel should be made of a hardened tool steel that is highly polished and free from tool marks, scratches, or other imperfections. Hardness is needed merely to serve as a protection against damage due to handling during the production cycle. The mandrel is not subjected to hobbing, heat, or other stresses, as is the case with beryllium copper castings.

For making pilot models or a small number of cavities, the master mandrel may be of soft steel, brass, or even plastic. High-temperature acrylic plastic or any of the thermosetting materials may be employed for this purpose.

One or two master mandrels will produce an unlimited number of cavities without the slightest damage to the mandrel. Since each electroformed cavity exactly reproduces the surface finish of the master mandrel, it is very important that the master have a finish that will be acceptable on the molded parts.

After suitable mounting and preparation, the mandrel is immersed in a nickel bath and becomes the cathode. After a deposit of pure nickel to a thickness of about one-

quarter inch has been attained, the solid nickel shell is stripped from the mandrel which is then used for the next cavity.

During the electroforming cycle the plating solution is circulated very rapidly and filtered constantly to remove impurities. Temperature of the bath, pH, current density, and electrolytic purification are controlled automatically during the production operation.

The electroforming of plastics mold cavities is performed in two phases. First, a layer of hard nickel (with a Rockwell "C" hardness of 40-50) is deposited in contact with the master mandrel to provide the hard inner surface of the cavity. This layer is usually about 0.123 inch in thickness, but the thickness may be varied for specific applications. Second, a back up layer of regular nickel (with a Rockwell "B" hardness of 90) is deposited to bring the cavity to final size.

Nickel Deposition

At the completion of the electroforming operation, enough nickel has been deposited to permit turning the cavity down to desired exterior size. In addition, the cavity is usually made about one-quarter inch oversize to permit trimming to length.

The mandrels can be mounted on an endless conveyor which rotates the mandrels as it moves them through the bath. Plating time and thickness of deposit are controlled by adjusting the speed of the conveyor.

For comparatively simple shapes involving no undercuts, a thin layer of a parting medium is applied to the mandrel to permit ready separation from the plated form. Parting agents such as beeswax, carbon black, collodion, turpentine, and others allow plating over the mandrel, but prevent the formation of a strong bond between the mandrel and plated metal. For complicated parts that contain undercuts, fusible mandrels made of a bismuth-lead eutectic alloy are used. These mandrels are centrifugally cast in the desired shape. After the part has been formed, the mandrel is melted out in a hot oil bath. The alloy is recovered and recast for further use.

With permanent mandrels, tolerance of ± 0.0005 inch are no problem since the mandrel can be machined and ground to desired size. Thickness and outside tolerances of the formed part are controlled by adjusting the plating bath. Tolerances of ± 0.001 inch an external dimensions are easily held in production. Tight tolerances are also possible with fusible mandrels if properly cast and machined. In general production work, tolerances of ± 0.002 inch are usually maintained when using fusible mandrels so as to avoid the time and expense required by greater precision.

Advantages and Applications

Owing to the interesting advantages of the electroforming process, a wide range of applications has already been developed. These advantages or features of the process include the obtaining of cavities having beautiful interior finishes; reproducibility of cavities; no damage to the master mandrel; cavities have hardened interior surfaces obtained without the use of heat; and perfectly-matched cavity halves obtained without irregular parting lines.

Since the electroformed cavity exactly reproduces the finish of the mandrel, mirror-finish cavities that do not require any hand polishing can be made by simply controlling the finish on the master mandrel. This offers very great attraction to the maker of pen and pencil barrel molds where polishing of cavity interiors is very difficult and costly, and offers the risk of varying cavity size.

All cavities made from the same master mandrel are completely identical and reproduce the exact size of the master. Thus electroforming offers an excellent method for making cavities of high precision. This is of great importance in the making of molded nylon gears. Controlled pitch diameters are very critical in such cavities, and hobbing often cannot be depended on to produce the desired dimensional tolerances. Another application is the making of deep cavities, such as for pen barrels, which are not easily obtained with other mold making methods.

No Heat Stress

Since the master mandrel is merely immersed in a slightly warm solution (the plating bath) and is not subjected to heat or stress, there is no danger of cracking or distorting the master. It should be noted that masters often are the result of long hours of hand work and are almost impossible to replace. Electroforming thus safeguards the master mandrel.

The electroforming process makes the cavity follow the contours of the master. Therefore, the length of the cavity and its exterior size and shape are of little consequence. Deep octagon-shaped pencil barrel cavities, tapered medicine droppers, and compound gears are some of the applications which are attained easily by this process, but would represent major problems when made by other means.

Unusual surface finishes and designs may be reproduced by electroforming. If a satin or "two-tone" finish appears on the master, it will be copied automatically in each cavity. Reproductions of a leather finish or of diamond facets are no problems to electroforming.

Cavities produced by electroforming have interior surfaces that are hardened without the use of heat to a greater depth than could be obtained by heat-treating steel. This required hardness is achieved by the use of addition agents in the electrolyte. The process eliminates the danger of cracking, distortion, or discoloration presented by heat-treating.

A method has been developed for making two perfectly matched cavity halves of hard nickel by the electroforming process, starting with an initial wax master. Expensive machining, blueing, and hand-matching of cavity halves are eliminated by this method.

Conclusions

The development of the electroforming process offers new possibilities for the design of plastic parts; an easier method of achieving results that previously were either uneconomical or impossible; and an improved quality of tooling to meet today's size and fine finish requirements.

The process is not intended to replace such conventional methods as hobbing for making cavities. Where cavity shapes are such that they may be hobbed easily, that method is still the cheapest and most desirable to use. In addition, cavities with heavy wall thicknesses needed to make very large items are not ideally suited to electroforming. However where the ease of making a wax or plastic master can be compared to the cost of hand-engraved hob, electroforming may provide substantial savings in cost and delivery time.

The electroforming process offers one more tool by which the plastics industry may reach fields into which it has previously hesitated to go. As is the case with all processes, it gives impressive results when used properly. As more and more plastics personnel are educated in the advantages and limitations of the process, it will take its place with other methods as an accepted tool of the plastics industry. ★ ★

Trademark Abuses and Relief

Gustav Drews

Brooklyn Law School

. . . trademark protection is valuable, but there are a number of abuses to be guarded against . . .

IN ORDER TO AVOID any misunderstanding as to the nature of the abuses to be discussed, a brief description of a trademark and the protection ordinarily accorded will be discussed.

In the interest of brevity and simplicity, the discussion will be limited to a trademark as distinguished from a service mark. A service mark has to do with services rendered, such as the name Waldorf Astoria for the New York hotel which renders hotel services but does not sell any goods under the name Waldorf Astoria, whereas a trademark is a mark used to identify goods which are actually sold in the trade.

A trademark **per se** may consist of a word, symbol, letters, numerals, or a combination of any two or more of the same. Under some circumstances a trade dress functions as a trademark, but rarely is acceptable for registration.

The trademark, within limits, should not be descriptive of the goods, have a geopraphical connotation, nor consist of a personal name. Furthermore, in order to be protected by a registration in the United States Patent Office, the goods sold under the mark must be sold in interstate commerce.

The protection accorded such marks in the United States when not registered generally depended upon an injunction and damages. When the trademark was not registered, the wrong depended upon an abuse of a competitive position. Consequently, if the first user of the trademark was engaged in trade only on the eastern seaboard to the exclusion of the western seaboard, and the second user was only engaged in trade on the western seaboard, to the exclusion of the eastern seaboard, and therefore not in competition with the trade of the first user, the first user could not prevail.

Furthermore, if the first user in the United States did not have any registration in the United States, denominated a home registration, a number of countries foreign to the United States would not grant a registration on such trademark, and thus would invite pirates in the foreign country to register the trademark and thus bar the United States trader from shipping into such country, goods bearing its trademark.

Furthermore, with or without a United States registration, the mere threat of an injunction and damages would not deter some infringers. As an instance, where the article required a small investment and the infringer operated in the name of a corporation which did not have substantial physical assets, in the event of a suit, before a final adjudication could be obtained, the infringer could have disposed of its infringing items and then the injunction and the awarding of damages would be meaningless. Wrongdoers quickly perceived this weakness in trademark protection and consequently when a suit resulted in an injunction, they would merely form new corporations and start their operations at other addresses.

Certain merchants, and unfortunately some of the larger merchants, would frequently use a trademarked item which was extensively advertised as a leader or "come-on" item to attract and sell such items by offering the same at ridiculously low prices, sometimes at cost and sometimes even at prices below cost. Small merchants in the vicinity of such merchants were consequently deprived of any business in such item. Manufacturers in turn could not afford to offend the larger merchants and were helpless to aid the smaller merchants. This practice became so wide-spread that it grew into a menace to fair dealing.

With the foregoing weaknesses in mind, one of the first trademark laws, enacted in 1881, extended the protection of a trademark to all of the states of the union, barring the acquisition of trademark rights by a second user of the trademark. This act also empowered the registrant to sue in the United States courts. While there is no intention here in any way to impugn the honesty of the state courts, it is of course reasonable to assume, particularly in a period of enmity between two states, that the courts in the jurisdiction of the infringer might be sufficiently biased to favor the infringer if he was opposed to a resident of a state at odds with the state of which the infringer was a resident. For this reason, the selection of a federal court where the office of the judge endured for life and was not dependent upon local favor, was frequently considered advisable in close cases.

With regard to merchants engaged in foreign trade, it was found, particularly in the period prior to 1920 in which there occurred a definite expansion in the export trade of the United States, that a number of foreign pirates anticipating the arrival of certain extensively advertised items from the United States, registered in their countries, marks which required home registrations in the United States and which were not registered in the United States. Among these marks there was one definite group, that which consisted of personal names, such as the names Dodge and Ford for automobiles. Not only the 1881 trademark law, but the 1905 trademark law, did not provide for the registration of names which were primarily family names. Consequently the names of these products could not be registered in the United States Patent Office. Some of the merchants who were thus unable to obtain home registration were placed at the mercy of pirates in foreign countries who would take out registrations in such foreign countries and then force the United States merchant either to eliminate its trademark or else submit to an exorbitant blackmail fee. In view of the foregoing, the 1920 act was passed which permitted the registration of trademarks which previously were rejected as personal names if, and after, they had been exclusively used for one year. The one year requirement was based upon the assumption that if a mark had been exclusively used for one year, a secondary meaning had been established to support the contention that the name had become distinctive of the item to which it was affixed. The Supplemental Register now in force in this respect continues the relief afforded by the 1920 Act.

The third abuse, namely the pirating of trademarks by so-called insolvent corporations, became so wide-spread particularly after World War I that trademark lawyers throughout the United States agitated for some legislation that might deter if not eliminate this abuse. The Congress of the United States was sympathetic, but loath to take action. Finally, however, the state legislators took up the matter and evolved the plan of permitting criminal action by the state against such trademark pirates and imposed not only a monetary penalty but also a jail sentence for the wrongdoers. After action under these statutes started, this piracy was materially reduced and at any rate reduced sufficiently to eliminate it as a menace.

With regard to the practice by large retailers to select as leaders certain extensively advertised items and marking down the price of the same below a price at which the small merchant could compete, the states here too initiated a possible relief. In a number of states, laws were passed permitting the fixing by manufacturers of resale prices to the consumer and some states also passed laws barring the selling of items below cost. The resale price fixing practice, however, could only be pursued in intrastate commerce up to August 17, 1937, since the federal courts had theretofore interpreted the antitrust laws as forbidding the fixing of resale prices by manufacturers. In order to obtain relief it was therefore necessary where interstate commerce was the dominant commerce of an industry to exempt such practice from the antitrust laws. Such a law was approved August 17, 1947 and entitled the Miller-Tydings Resale Price Maintenance Law. On July 14, 1952, this law was radically revised and enacted as the McGuire Fair Price Act. According to this Miller-Tydings-McGuire legislation, if a state permitted the fixing or establishing of resale prices to the consumer, then interstate sales at fixed prices in such state would be made exempt from the federal antitrust prohibition. As a result of this legislation, in those states which had fair trade laws, this cutrate practice was brought under control.

Although the legislatures granted material relief with regard to technical trademarks, there still remained an extensive area involving trade dress imitations where statutory help could be used to good advantage. Instances in this area were characterized by the fact that the first or legitimate user had built up an extensive following and the wrongdoer was trying to trade upon the goodwill so created, just as was the case with extensively advertised trademarks. The wrongdoer, however, would avoid imitating the technical trademark, if any, associated with the trade dress and concentrated upon the overall assembly or trade dress of the article. In some cases, the originator produced a distinctive shape for the container, in another a distinctive arrangement of colors, and in still others a distinctive arrangement of the printed matter on the label attached to the item or the carton containing the item. The shape of the container or item itself might have been well known and not open to protection by patent. The United States Patent Office and the courts have been loath to grant monopolies on color arrangements. The protection of printed matter on labels could be obtained by copyright. As to the qualities of the subject matter protected, the Commissioner of Patents at one time stressed artistic quality (See Ex parte Palmer, 1892 C. D. 6.) Later on as a result of a decision in the 8th Circuit Court of Appeals in Fargo v. Brechet, 295 F. 823 (1924) artistic quality was no longer considered and it appeared sufficient if the subject matter consisted merely in printed matter of original recipes with directions for making various items of food and drink, regardless of the status of a fanciful emblem, if any, which accompanied same. The difficulty, however, with which the copyright owner was confronted was the degree of imitation perpetrated. Some of the decisions stated that the part taken must as a rule be substantial and material in relation to the work as a whole. (See the decision of the 2nd Circuit Court of Appeals, Wilson v. Haver Brothers, Inc. 275 F. 346 (1921). This, of course, presented the problem that the part considered to be substantial and material in the opinion of one judge, might not be substantial and material in the opinion of another judge. For this reason, copyright protection was hazardous and unreliable.

The result was that very little resort was had to statutory protection and relief was sought more and more in actions based on unfair competition. The courts in such actions complicated the difficulty of protecting this type of item differentiation in requiring evidence of actual confusion or actual palming off before granting relief. Consequently, in some instances the plaintiff would be required to embark upon an expensive investigation program to gather sufficient instances of confusion or palming off to support its action. Although the courts have granted relief in a number of instances, it is believed worthy of consideration and study that either the state legislatures or the federal legislature or both, review the possibility of enacting a law similar to some of the state laws involving technical trademarks, imposing a fine and imprisonment, and also review the possibility of dispensing with the necessity of introducing evidence of palming off to support an action for unfair competition. ★ ★

Edited by Louis Paggi, *E. I. du Pont de Nemours & Co., Inc.*

CAUSES OF SURFACE BLISTERS

L. Paggi
Consultant

Among the various problems confronting the molder from time to time is the elimination of surface defects from the molded item. Ranking high in the list of these defects are those caused by bubbles or blisters on the surface of the molten material entering the cavity. The terms used to describe these defects are numerous and include "fisheyes", "mica marks", "blisters", "splay marks", "streaks", smears and "pitting'. For lack of a better universal term they will be referred to, herein, as "blisters". The term "blisters" will not include the surface scaling defect also known as "fish scale" which is a surface laminar structure resulting from purposely or accidentally blending and molding of two incompatible materials.

Blisters have their origin in a gaseous substance expelled from the molten plastic. The identity of the expelled gas will vary with the formulation of the plastic material as well as the conditions under which it is processed. For example, it may be a product of thermal degradation of the plastic or simply absorbed or absorbed moisture or solvent.

Appearance of Defect

The surface defect may assume a different appearance depending on the following factors:

1. The formulation of the plastic material being molded.

2. The conditions used for processing.

3. The identity of the low boiling substance or of inclusions.

The situation may exist where more than one factor is responsible for the generation of low boilers and expulsion of gases which form blisters.

Where more than one adverse condition exists, correction follows a simple process of elimination.

To assist in analyzing the problem, the following breakdown of the mechanics involved may prove helpful.

Behavior of Gas

The existence of a gas is dependent on temperature and pressure. For example, water is a liquid between approximately 32°F. and 212°F. at atmospheric pressure. If the pressure is increased, the temperature at which gaseous water will be evolved will be proportionately increased. If the pressure is reduced, the reverse is true. Since all gases respond to the same laws, the use of high molding pressure, relatively long plunger-in-time and short delays between molding cycles all tend to reduce the possibility of gas evolution. If, on the other hand, the temperature of water is increased, the pressure necessary to maintain the water in the liquid phase must also be proportionately increased. Again comparing this process to the molding of plastics we may find that the temperature used is much too high to be compensated for by available pressure and cycle conditions.

It follows then that evolution of gases can be minimized by use of lower molding temperature.

It is quite obvious that the problem of blisters cannot always be eliminated by the simple expedient of altering temperature or pressure. We must, therefore, consider other factors responsible for the generation and expulsion of gases from the molten plastic.

Generation of Gases from Water

The most common and perhaps most troublesome source of gas is water which has been adsorbed or absorbed from the atmosphere. Certain plastics have a strong affinity for water. Formation of blisters may be a problem with these unless the material is maintained sufficiently dry during processing. However, it does not follow that plastics with low affinity for water will not have blistering problems due to the presence of water. In fact, unless moisture is slightly compatible with the molten plastic, small percentages of adsorbed or surface moisture can result in blisters simply as the result of physical entrapment of the moisture between the compressed plastic particles within the plastifying cylinder.

Drying of the material is the obvious answer to elimination of blisters caused by the presence of water. Here, the use of a dehumidified oven is essential.

Generation of Gases from Solvents

During the compounding or manufacture of certain plastics, solvents may be used at some stage of the operations. These solvents are generally sufficiently eliminated from the molding powder to permit trouble-free processing. Occasionally however, sufficient quanties of solvent remain in the material resulting in the formation of blisters. This is particularly true of some surface coated granules or of plasticized materials. Here again, drying of the molding powder as recommended by the material supplier will eliminate the trouble.

Generation of Gases Due to Polymer Degradation

While all plastic materials offered to the molder have sufficient thermal stability to permit trouble-free processing under normal conditions, no plastic material can be maintained at normal processing temperatures indefinitely without suffering some degree of thermal degradation. Depending on the material formulation, the safe exposure time to molding temperatures will vary from several minutes to a few hours.

The presence of blisters in an item molded from dry material is a good indication that degradation has taken place. The absence of blisters however, does not indicate that degradation has not taken place. Some polymers, for example polyethylene, can degrade without the formation of blisters. The reason for this is that in such cases, gases given off during degradation are soluble in the plastic over a wide temperature range and therefore reabsorbed when molding pressure is applied and the material cools. In other cases where the gases are insoluble, or soluble only in very hot plastic, degradation frequently is evidenced by blisters.

An item having a poor surface, although otherwise acceptable, will very often meet with sales resistance and it is only natural to be most concerned with this problem. However, degradation is a condition which should be tolerated even though the item produced has an acceptable surface and is saleable, because the physical properties will be below standard.

Determining the Source of Blisters

It is often difficult to distinguish by the appearance of the molded

item between blisters caused by moisture or solvents and blisters caused by degradation of the plastic. When the processing conditions are known, however, it is not too difficult to isolate the cause.

For example, certain cellulosic molding compounds will lose a certain percentage of plasticizer when subjected to a drying operation and when molded at relatively high molding temperatures.

Plasticizer Loss

With each successive reworking of this material, more plasticizer is lost and the molding range becomes narrower. The point will be reached where, because of low plasticizer content, the material will have poor flow and therefore, require higher temperature to fill the mold. The higher molding temperature will cause rapid degradation of the material resulting in a scaly surface and poor welding properties. To isolate the cause of blistering in this material is simply a matter of checking the molding range. If the material will flow well at what might be considered a lower than normal molding temperature, blistering is probably due to the presence of low boilers which can be eliminated by drying. If the material requires higher than normal temperatures to achieve the expected flow properties, the material is low in plasticizer and should be worked off by blending small quantities with virgin material, or it should be reprocessed or discarded.

Certain polymers, such as acrylic or nylon compounds, behave very similarly to the cellulosics with respect to the flow test. Generally speaking the presence of low boiling compounds will cause the material to flow with greater ease at lower temperatures. Here again drying will eliminate the cause of blistering.

Controlled Drying

Controlled drying is of the utmost importance to the molding of many plastic compositions. Since in many instances, flow properties are also affected by drying it is possible to overdry. It might be well to mention at this point that overdrying is not a matter of drying for a few hours over the recommended time but rather by doubling or tripling the recommended time. The correct drying procedure for any plastic composition will involve control of time, temperature and humidity of the atmosphere.

Blistering

Blistering caused by thermal degradation can take place even in correctly dried material. This is usually a function of:

a. Prolonged heating at normal temperatures such as may occur when using disproportionately large heating cylinders on low volume shots or when an excessively hot spot is present in any zone of a heating cylinder.

b. When the mold is filled too slowly thus permitting the blister at the surface to solidify before the full molding pressure is developed in the cavity.

c. When the mold is filled too fast, thus resulting in turbulence, shearing or tearing of the melt and generating high temperature as the result of friction through a gate or thin section of an item.

It will be found that certain materials in conjunction with certain molds have a critical rate of filling while others are not at all critical.

Appearance and Causes

While it is true that appearance of the surface alone cannot always be used to determine the cause of blistering, it can be very helpful as a guide to the source.

The following tabulation is given for this purpose.

Appearance of the Surface

Fiber-like structure in cellulosics.
Mold surface cannot be reproduced on article.
Isolated unbroken blisters puffed above plane of surface.
Localized patches of smeared material having a porous structure with remainder of surface normal.

Possible Cause

Material has lost plasticizer by overdrying or reworking.
Material has high melt viscosity due to overdrying. Injection rate too slow or too fast.
Material dislodged from a hot spot in the nozzle or front zone of cylinder.

Appearance of the Surface

Numerous broken blisters very small and circular with a hemispherical cross-section.
Numerous open craters very small and circular with a "W" cross section.
Broken or unbroken blisters very shallow, varying in size and elongated in the direction of flow.
A streak or stream of broken or unbroken blisters or bubbles at or near the surface.

Possible Cause

Material is degraded due to overall high temperature or indicates the presence of solvent or wetting agent on surface coated granules.
Presence of contamination of small particles which are infusible at the molding temperature.
Wet or overheated material. Low molding pressure and low rate of mold filling.
Due to a local hot spot in the nozzle or cylinder or the material is not uniformly dried. ★★

Contributions to the features Molding Cycles and SPEaking of Extrusion will be welcomed by the editors of these features. Comment on published material, additional information on the subject of a column, or criticism will be equally well received and considered for publication. Complete articles may be submitted, and suggestions for topics to be covered are solicited.

Your interest will be helpful and much appreciated.

The Editors

Plastics for Roof Construction

Fee for the two-day session will be only $20 including two luncheons, bus tour and your copy of the published proceedings of the conference. Send names to be added to the mailing list to Harold Horowitz, BRI Technical Secretary, 2101 Constitution Ave., Washington 25, D. C.

Topics covered will be: "Phenolic Foam as Thermal Insulation," "Thermoplastic Foam as Thermal Insulation," "Vinyl Film as Vapor Barrier," "Service Criteria and Performance Requirements for Flashing," "Plastics Flashing Material," "Architectural Requirements for Roofing Materials," "Roof Structures Constructed of Plastics Materials," "Sprayed Vinyl Coatings," "Plastics and Elastomer Modified Asphalts," "Neoprene as a Roof Coating," "Thermosetting Plastic Skylights," "Thermoplastic Materials for Skylights."

Architectural Design and Coordination, Job Management and Organization of the Work, Management Objectives and Supervision, Fabrication and Erection of Plastics Components, Open Discussion.

Finale—Tour of the New Monsanto Inorganic Chemicals Laboratory.

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Programs on Page 52

SPEAKING OF EXTRUSION

Edited by R. D. Sackett
Technical Service Associate
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Extrusion Equipment

H. M. Whitcut
Development Engineer
Faucett Finney Ltd.

This article has been abstracted by the editor from Mr. Whitcut's lecture presented at the "The Rubber and Plastics Age" symposium on "Extruded Rubbers and Plastics" held in England in October 1956. The article in its entirety appeared in the January 1957 "Rubber and Plastics Age".

Extruders are widely used, not only for the manufacture of finished sections such as pipes, film, coated paper, sheet and cable, but also for mixing and blending work. Many papers have been written about such machines, and their integral parts, but at times the sole function of the machine has been lost sight of, it being simply to present material in the correct state uniformly and continuously to the extrusion die.

In so far as an extruder does this it is a good machine; if it does not, it is a bad one. With a sufficiently experienced operator, blessed with unlimited time, ingenuity and patience, no doubt a mincing machine would fulfill this qualification. So in practice there are four further requirements:

The extruder, commensurate with its size, must have as high an output as possible.

It must be capable of running continuously for as long as possible without breaking down or otherwise failing to fulfill its sole function.

It must be capable of being operated successfully with the minimum of attention or skill on the part of the operator.

It must be possible to adjust its output from a minimum to a maximum, preferably without stopping; in other words, the machine must be flexible in operation.

These requirements may seem self-evident, but their importance is often not fully realized; many fabricators in the past having been content to place more emphasis on the initial price of a machine. However, when it is realized that an extruder costing, say, $14,000, may process during its life more than $700,000 of material, while it has also been shown that a 10 per cent increase in production rate alone will justify between 15 per cent and 25 per cent extra machinery cost for a given return on capital, it can be seen that the price of an extruder is of secondary importance. From a cost point of view, in fact, production rate is the main consideration, labor and plant depreciation are relatively unimportant and power costs are negligible.

It is difficult to give much guidance concerning the output of extruders in view of the over-riding effect of the cross-sectional area of the extruded section, but the author has obtained the following results when extruding small sections such as covered wire at 90 r.p.m.

Material in pounds per hour

Size of Machine	Hard PVC*
1½"	30
2 "	70
2½"	110
3¼"	220
4½"	400
6 "	750

**20% Plasticizer*

General Construction

The mechanical design must be sound, and the various parts robustly constructed and of sufficient size to avoid overstressing. In this respect the head attachments, and in particular the main thrust bearings, deserve special consideration. Figure 1 shows, for instance, the relationship between bearing life and screw speed of typical bearings used in a variety of current types of extruder. It is obvious that with a high production, high screw speed machine, a very large bearing is required to give, at maximum screw speed, a life which should certainly exceed 40,000 hours.

Drive

A drive of sufficient power should be fitted. This in particular has been a failing of many British extruders in the past, but today with high output machines, the following size of drive should not in any way be considered excessive:

1" Machine	5 h.p.
2" Machine	15 h.p.
3" Machine	50 h.p.
4" Machine	75 h.p.
6" Machine	150 h.p.

These figures refer to the h.p. which should be available when the extruder is working at full capacity.

Even if constant torque drives of these sizes are used, no difficulty should be encountered in starting a machine even with a full screw. Consideration should also be given, however, to drives which will deliver a higher relative torque at low screw speeds, in view of the non-straight-line power requirements of extruders in general.

Requirements vary considerably in different applications, but ideally the drive should not only be capable of maintaining a constant speed, but should be adjustable so that the screw can be driven at any speed from zero to full r.p.m. without the use of change-speed gear-boxes. These, although useful, especially in an underpowered machine, involve stoppages, and lead to discontinuities in production. In any case, the wider the speed range of the drive the better.

Some safety overload mechanism should also be included, such as an electrical overload cut-out, or a shear pin on the drive assembly, to prevent damage to the machine in the event of any extraneous matter dropping into the screw. The latter alternative is, of course, less convenient than the former.

The reduction gearing and, in fact, all the moving parts of the extruder, should be designed so as to transmit as much as possible of the available h.p. to the screw, and so to the material being extruded. This will require an efficient lubrication system and adequate seals to prevent intermixing of lubricating oil and the plastic material, with preferably an over-riding safety device so that, in the event of a seal failing, oil will drain out of the machine rather than into the barrel.

The Screw

The design of the screw involves more problems than any other part of an extruder. Of these the following are of great importance:

1. Pitch. The smaller the pitch the greater the positive thrust of the screw but the smaller the screw throughput. Closer pitches also give more mechanical working and greater pressures.

2. Number of Starts. A multi-start screw of the same pitch as a single-start screw will give reduced thrust, but the theoretical volume discharge will be increased, and the linear speed of passage throughout the extruder increased. If the helix angle is maintained constant, increasing the number of starts will result in a reduction of the possible volume discharge, because of the flights, although the screw area available for heat transfer will be increased.

An increased number of starts with a constant helix angle will also aid the feeding of strip material, while it is possible to have a slightly deeper screw at the feed end without reducing strength.

Multiple-start screws, however, often lead to pulsations in the feed rate owing to the difficulty of exactly balancing the volume of each flight.

3. Profile. The profile of the screw will affect the shear rate and heat transfer characteristics. Thus, shallower screws will give higher shear rates and increased transfer of heat between the barrel walls and the material; but the shallower the screw the lower is the swept volume and theoretical discharge.

Shallow screws are usually associated with high pressures and hard materials and deep screws with low pressures and soft materials.

4. Compression Ratio. The material is normally fed to the screw in the form of granules, which have to be compacted to the final density of the material at the extrusion temperature. To generate sufficient pressure to compact and force the plastic through the die, a compression ratio is generally necessary. This consists of lowering the volume of the screw profile progressively from the feed to the delivery end. This can be achieved by several methods, usually by increasing root diameter, decreasing pitch, or a combination of both. Constant pitch appears to be the most desirable, as this gives maximum heat transfer and tangential shear as well as being the most economical type of screw to manufacture. All screws have in effect a feed section, a compression section and a metering section, although these run into each other with most materials. Nylon, for example, has such a low melt viscosity that all the compression may occur in one part of the screw and the decrease in depth or pitch is therefore not constant over the whole length of the screw.

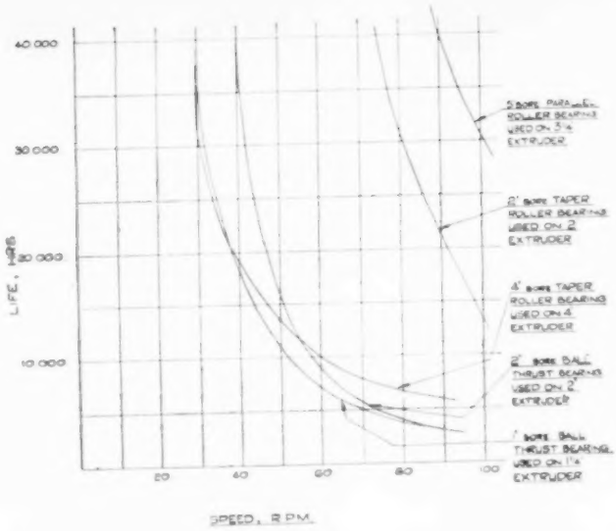


Figure 1. Life of extruder bearings depends on speed of screw.

5. Length and Diameter. The pitch at a fixed helix angle is directly proportional to the diameter of the screw, so that it is necessary to consider the length and diameter as being interdependent. Screws are then classified according to their length/diameter ratio. When we consider the melt characteristics of different materials we must conclude that a length/diameter ratio suitable for one may be unnecessarily large if applied to another; the additional screw length serving only to restrict the flow, resulting in reduced output. Also the greater the length of the screw, the greater the amount of mechanical working.

A short screw will thus lead to incomplete mixing, with consequent uneven temperatures, while a very long screw may lead to decomposition with unstable materials such as rigid PVC. With comparatively soft materials such as polyethylene, however, a longer screw can be rotated faster, with greater outputs, without cold material being fed to the die. It should not be forgotten that with a given length/diameter ratio screw, the larger the diameter the further the path which the material has to travel. Thus relatively lower length/diameter ratio screws are needed with larger machines.

6. Temperature. The coefficient of friction between metal surfaces and some thermoplastics increases rapidly with temperature. A screw surface cooler than that of the barrel wall is therefore often desirable to assist mixing and forward travel. The screw should thus be cored for water-cooling. Generally better results are obtained if the cooling water is led to the front end of the screw (3).

7. Other Features. The higher the surface finish of the screw the more efficiently will it act as a pump. Also in the interests of cleaning the surface should be as smooth as is practicable.

The screw should be made of high-quality steel with as hard a surface, particularly land surface, as possible to reduce wear.

The above is merely a statement of the different screw variables. The operation of the screw is a complex one involving feeding, pumping, compressing and mixing. It would be impossible in one paper to consider all variables in relation to the particular needs of each material, and thus arrive at the design of the perfect screw, even if all the necessary data were available. Working from practical experience, however, it is the author's opinion that for the two common materials, PVC and polyethylene, the following screws represent the present optimum in design.

General

Hard chromium-plated and polished all over, made from alloy steel hardened on the lands. Pitch roughly $1\frac{1}{2}$ x diameter single-start with vertical thrust faces on first $1\frac{1}{2}$ turns of the lands to aid feeding, thereafter radiused to avoid stagnant areas.

PVC

Compression ratio approximately 2 to 1.

Delivery depth from $\frac{1}{8}$ in. on a $1\frac{1}{2}$ in. machine to $\frac{3}{8}$ in. on a 6 in. machine.

Length/diam. ratio from 18:1 on a $1\frac{1}{2}$ in. machine to 12:1 on a 6 in. machine.

Polyethylene

Compression ratio of up to 4 to 1 can be used.

Delivery depth can be down to 50 per cent of those given above.

Length/diam. ratio from 18 to 25:1 on a $1\frac{1}{2}$ in. machine to 12 to 15:1 on a 6 in. machine. ★★

Report on . . .

International Standards Organization

Seventh Annual Meeting

Norman Skow

Synthane Corp.

ISO/TC 61 held its Seventh Annual Meeting at the Palace Hotel, Burgenstock, Switzerland, July 8-13, 1957. Ninety-five delegates from fifteen participating member countries and one delegate from an observer member country were in attendance. Observers were present from the International Electrotechnical Commission (IEC), the International Union of Pure and Applied Chemistry (IUPAC) and the International Congress on Plastic Materials (ICPM).

Six test methods for plastics were approved for circulation to member countries as draft ISO Proposals, six methods were approved for circulation to member countries as Draft ISO Recommendations and four methods were approved for submission to the ISO Council for final action. These methods are listed at the end of this news item.

The American delegation at this meeting consisted of C. Howard Adams, Robert Burns, Gordon Kline, A. C. Webber, Norman A. Skow, Ralph Witt, E. Y. Wolford and P. E. Willard. We are proud to say that most of these delegates are members in good standing in S.P.E. Norm Skow attended as the official S.P.E. representative.

ISO (International Organization for Standardization) has as its objective the development of standards in the world with a view of facilitating international exchange of goods and services and the development of mutual cooperation in the sphere of intellectual, scientific, technological and economic activities. ISO/TC 61 deals exclusively with Plastics.

The Eighth Annual Meeting of ISO/TC 61 will be held in Washington D.C. November 3-8, 1958 and again S.P.E. will take an active part in this important activity.

Methods Approved for Circulation to Member Countries of ISO/TC 61 As First Draft ISO Proposals:

1. Determination of Tensile Properties of Plastics.
2. Recommended Practice for Compression Molding Test Specimen of Thermoplastic Materials.
3. Recommended Practice for Injection Molding Test Specimen of Thermoplastic Materials.
4. Recommended Practice for Compression Molding Test Specimen of Thermosetting Materials.

As Third Draft ISO Proposals:

1. Standard Atmospheres for Conditioning and Testing Plastic Materials. (Note: This is combination of substance of documents 121 and 122)
2. Determination of the Melt Flow Index of Polyethylene and Polyethylene Compounds. (Note: This previously circulated as second draft ISO proposal as Document 142)

As First Draft ISO Recommendations:

1. Determination of the Izod Impact Resistance of Rigid Plastics (Izod Impact Flexural Tests) (Note: Previously circulated as First Draft Proposal as Document 140).
2. Determination of the Charpy Impact Resistance of Rigid Plastics (Charpy Impact Flexural Test) (Note: Previously circulated as First Draft Proposal—Document 139).
3. Incandescence Resistance of Rigid Self Extinguishing Thermosetting Plastics (Note: Previously circulated as First Draft Proposal—Document 141).
4. Thermal Stability of PVC and related Copolymers and their Compounds by the Congo Red Method (Note: Previously circulated as First Draft ISO Proposal—Document 123).
5. Thermal Stability of PVC and related Copolymers and their Compounds by the Discoloration Method (Note: Previously circulated as First Draft ISO Proposal—Document 124).
6. Bleeding of Colorants from Plastics (Note: Previously circulated as First Draft ISO Proposal—Document 125).

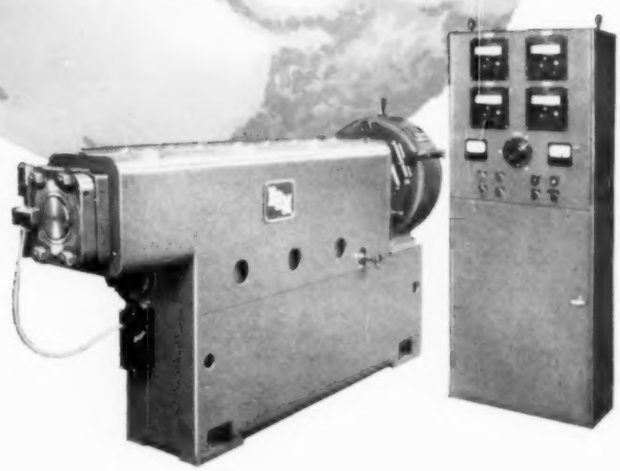
Methods Approved for Submission to ISO Council

1. ISO/TC 61 (Secretariat-71) 108—Draft ISO Recommendation No. 121. Determination of Boiling Water Absorption of Plastics (Conventional Method)
2. ISO/TC 61 (Secretariat-72) 109—Draft ISO Recommendation No. 122. Determination of Percentage Methanol Soluble Matter of Polystyrene.
3. ISO/TC 61 (Secretariat-73) 110—Draft ISO Recommendation No. 123. Determination of Free Phenols in Phenol-Formaldehyde Mouldings.
4. ISO/TC 61 (Secretariat-74) 111—Draft ISO Recommendation No. 124. Determination of Free Ammonia and Ammonium Compounds in Phenol-Formaldehyde Mouldings (Semi-Quanitative Method).

10 reasons why NRM *thermoplastic* EXTRUDERS are "first choice" among plastics manufacturers and processors THE WORLD OVER...

1. "BALANCED HEAT CONTROL"
2. "CAST-IN" CYLINDER HEATING
3. "QUICK-OPENING" DIE GATES
4. ONE-PIECE 20:1 Le/D RATIO CYLINDERS
5. SINGLE WALL XALOY-LINED CYLINDERS
6. CONTROL CABINETS MEETING J.I.C. CODES*
7. RUGGED CONSTRUCTION THROUGHOUT
8. A COMPLETE LINE OF EXTRUDERS (UP TO 12")
9. MATCHED ACCESSORIES
10. FEED SCREWS FOR EVERY EXTRUSION NEED

*Joint Industrial Council



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WEST: S. M. Kipp, Box 441, Pasadena 18, Cal.
MID-WEST: National Rubber Machinery Company, 5875 N. Lincoln Ave., Chicago 45, Ill.
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Creative Engineering

Action— By Your National Organization

"The objects of the Society shall be to promote in all lawful ways the Arts, Sciences, and Engineering Practices and Standards connected with the utilization of plastics."

Open Letter to SPE Members

Dear Fellow Members:

A year ago in your July Journal I had the privilege of writing you on some ideas I had about our SPE. Now these "ideas" seemed to be long range. They were not mine in origin but by collection. They had been gleaned from our Journals, letters, books, and discussions with fellow members.

It is with humble pride that I review the wonderful progress that has taken place during this past year. Through the sincere efforts of you, the member, in the capacity of national and local officers, chairmen and committeemen, authors, speakers and educators, and with the fine staff at Athens and Greenwich, all of these "ideas" are beginning to take shape.

May I review a few of these for you. We have published and sold approximately 3,000 copies of our first technical volume, "Quality Control for Plastics Engineers" edited by L. Debing. Two more books are in writing and are due in publication late this year, "Injection Molding, Revision #1 by Islyn Thomas", and "Thermoplastics Processing" by E. C. Bernhardt. Jules W. Lindau, III, Administrator of our Technical Committees is looking for an author for our next volume "Thermosetting Processing." Our Inter-Society Relations Committees are under way and ready to serve our other committees, and are reporting to the fine new section of the SPE Journal, "The Technical Committees Report". Let's use I.S.R.! The Professional Activities Groups are getting well organized and offer a proving ground to each of you in a technical area of your choice, such as "Plastics in Electrical Insulation", "Plastics in Building", "Injection Molding" and eight others, all with many sub-committee potentials.

Jas. R. Davidson resigned as executive-secretary of SPE to become vice president and sales manager of Capac Industries, Inc., effective August sixteenth. Details are on page 63.

Injection molders, here is a chance for you to do something. Read your "Technical Committees Report" section for action in these areas.

Under the Administrative Technical Committees we see evidence of fruitage, through the real efforts of these committees, their chairman and Administrator, R. K. Gossett. We have, among many things from the Education Committee, a report on the colleges with curriculums in polymeric materials (August Journal), a book list on the books printed in English on plastics (October Journal), a brochure for the Sections toward better Section education programs (to be mailed in September). In the Meetings Committee we have published a guide to authors, "Write Now" (copies available by writing Greenwich), a "RETEC Procedures Manual", portions of an "ANTEC Procedures Manual" (with the complete manual expected late this Fall) and plans for the best ANTEC yet (Detroit, January 28th to 31st, 1958). Also, four outstanding RETEC's are planned for the rest of this year (Buffalo, Sept. 27th, Upper Midwest, Oct. 8th, Cleveland, Oct. 17th, and Los Angeles, Nov. 11th.) In the Publications Committee there is a big **surprise** for you in your Journal, and of course plans are being made to go to a full-time editor next year. The Administrative Operating Committees are not so glamorous but they are doing a big job. In credentials, membership, and other areas, there is work going on every day. There is a complete study under way in Constitution and By-Laws; a real big job is being done by Pribble and his committee. In Finance I am happy to report an assets picture of $62,075.17. Many others are carrying out fine projects, such as a search into "student membership for SPE", and of course the monumental program being carried on by the "Institute Committee" under the guidance of Past President Formo. For all of this I am quite grateful to you, the officers and our President.

Let us look ahead to new endeavors! A growth in numbers to 30,000, a continuing growth in stature, revised management structures, added publications, new Sections and other revisions in our concepts are necessary to make these ever-expanding goals attainable. Let us keep in mind that as we meet the challenge for SPE we assure our own growth.

Serving you has been my privilege.

With kindest regards,

Jas. R. Davidson

Regional Technical Conferences

Hot Runner Molding

BUFFALO SECTION

Hotel Niagara, Niagara Falls, New York
September 27, 1957 beginning at 10 a.m.

Hot Runner Molding—a review
Ernest P. Moslo, Moslo Machinery Co.

Automation in Hot Runner Molding
J. A. Kavanaugh, Standard Tool Co.

Materials for Hot Runner Molding
Richard W. Miler, Dow Chemical Co.

Luncheon

Practical Hot Runner Molding
J. R. Grenier, Protective Closures Co.

Panel Discussion
C. W. Kendall, moderator.

The last talk will be followed by a discussion period when all four speakers will participate in the symposium and either solve many problems or at least engender sufficient discussion to form individual conclusions on whether or not to utilize this molding approach.

Some 20 Sections of SPE within a 400 mile radius of Buffalo will be contacted through mailings and a goodly representative attendance is expected.

The Committee is: Haiman S. Nathan National Vice President Honorary Chairman; General Chairman, R. W. Miller; Program, Gordon Storin; Panel Moderator, C. W. Kendall; Publicity, J. P. Healey; House & Arrangements, P. Logel; Registration, A. Engle; Treasurer, K. L. Ditzel.

There is a wide interest in this phase of plastic molding and as it is most controversial it is hoped that this RETEC will clarify many of the problems and point the way for those now in doubt.

Registration fee is four dollars. For your reservation write to R. W. Miller, 3 Hillview Court, Lewiston, New York.

Isocyanates

UPPER MIDWEST SECTION

October 8, 1957
Curtis Hotel, Minneapolis, Minn.

The Upper Midwest Section of the S.P.E. is sponsoring an Isocyanate Symposium on Tuesday, October 8, 1957 and extends an invitation to all members of S.P.E. and other technical societies to attend this informative conference.

This is another in a series of regional technical conferences designed to bring up to date information on the ever growing family of plastics materials before industrial leaders as well as to allow the interchange of ideas of mutual interest.

The program, to be held at the Curtis Hotel in Minneapolis, Minnesota is as follows:

9:00 A.M. Recent Advances in Urethane Materials
Dr. C. H. Wilson, Dr. W. L. Riedeman, University of Notre Dame

A Comparison of Properties Between Polyester and Polyether Based Isocyanate Foams
M. J. Sanger, G. T. Gmitter, E. M. Maxey, The General Tire and Rubber Company, Akron, Ohio

Flexible Urethane Foams Derived From Polyethers
S. Davis, J. M. McClellan, M. C. Frisch, Research Laboratories, Wyandotte Chemicals Corporation, Wyandotte, Michigan

Question and Answer Period

12:00 Noon Lunch

1:30 P.M. High Temperature Urethanes
V. V. D'Ancicco, Carwin Polymer Products, Inc., North Haven Connecticut

Rigid Urethane Foams
M. E. Bailey, R. C. Kuder, Allied Chemical and Dye Corporation, Buffalo, New York

Molding of Resilient Urethane Foams
R. E. Knox, W. J. Touhey, E. I. duPont de Nemours, Wilmington, Delaware

Storage Characteristics of a Polyurethane Resin
Dr. Joseph G. Fuono, U. S. Naval Powder Factory, Indian Head Maryland

Question and Answer Period

Advanced Registrations may be sent to Mr. William Brooks, 1839 Carl St., St. Paul 8, Minnesota.

Registration Fee $4.00

Preprints of talks will be made available.

Polyethylene—Properties and Uses

SPE — RETEC — Cleveland, October 17

"Polyethylenes—Properties and Uses" is the theme of the Society of Plastics Engineers Regional Technical Conference which will be held October 17 at the Hotel Carter in Cleveland, Ohio.

The program for the conference follows:

9:30 A.M. Polyethylene-Properties

Moderator: W. O. Bracken, Hi-fax Sales, Hercules Powder Co

Introduction and History of Polyolefins—J. K. Honish—Product Mgr., New Products, Bakelite Co.

Low Density Polyethylene—R. M. Campbell—E. I. du Pont de Nemours & Co.

Medium Density Polyethylene—F. C. Sutro, Jr.—Manager, Technical Service, Spencer Chemical Co.

Linear Polyethylene—G. H. Sollenberger—Technical Coordinator, Koppers Co.

12:30 P.M. Lunch

Luncheon Speaker: Bill Veeck, Baseball Promotor

2:30 P.M. Polyethylene-Uses

Moderator: F. A. Martin, Senior Section Head, Hoover Co.

"Blow Molding"—E. E. Mills, Consultant

"Injection Molding"—Milan Krajcik, Wooster Rubber Co.

"Pipe Extrusion"—Herbert Fackler, Vice-President, American Vulcathene Corp.

"Film"—C. J. B. Thor, Visking Corp.

Advanced reservations may be sent to Mr. E. J. Haskins at Zenith Plastics Company, 3901 Superior, Cleveland 14, Ohio. Make checks payable to Cleveland-Akron Section, S.P.E.

Registration fee: (Includes luncheon and preprints)

Advance	$ 9.00
At Conference	$10.00

Plastics for Airborne Electronics

SOUTHERN CALIFORNIA SECTION

Hard working chairmen, Leo Costanza and Robert Steinman of the Southern California Section of the S.P.E., have announced an unusually instructive list of papers for their forthcoming RETEC on airborne electronics. Subjects covered during the symposium will be:

1. "Effects of Hardeners on the Electrical Properties of Reinforced Epoxy Laminates"—R. M. Maybee
2. "Predication of Mechanical Properties Through the Determination of the Electrical Properties of Plastics"—J. Del Monte
3. "Electrical Properties of Plastics as Influenced by Cure Conditions"—J. J. Knudsen
4. "Dielectric Properties of Plastics—Controlled?"—Ed Burkart
5. "Urethane Coatings — Electrical Insulation" — Dr. M. E. Bailey
6. "Silicones in Electronic Systems"—K. H. Hoffman
7. "Encapsulations for Electronic Systems"—R. M. Houghton
8. "Polyurethanes in Electronic Systems"—Ben Carroll
9. "Plastic Coatings—Conductive and Insulating"—Albert Davis
10. "Printed Circuits"—Dr. L. H. Ott
11. "Plastics in Guided Missiles"—M. A. Nadler

In addition to the program above, there will be a luncheon address on "Plastics in the Earth's Satellite Project" which will be particularly informative and timely.

The symposium will be held on Monday, November 11th, at the Ambassador Hotel, 3400 Wilshire Boulevard, Los Angeles. Because of the length of the one-day program, the meeting will start promptly at 8:30 A.M., the committee has announced.

Any questions or correspondence concerning the symposium should be directed to — Mr. Walter H. Kadlec, E. I. du Pont de Nemours & Co., 2930 East 44th Street, Los Angeles 58, California.

Detroit Section 3rd Annual Conference
September 27-28

St. Clair Inn, St. Clair, Michigan

"Plastics for the Automotive Industry"

Moderator— G. M. Haviland, Fisher Body Div. of G. M. Corp.

Some Aspects of Automatic Injection Molding
Mr. D. Larmee
Brooklyn Plant, Ford Motor Company

Vacuum Metallizing and Its Relationship to the Automotive Industry
Mr. Milton Z. Thorson, Vice President
Red Spot Paint and Varnish Company

Re-Evaluation of the Use of Pre-Mix Molding Compounds
Dr. J. N. Epel, President
Duralastic Products

The Potential of Printed Circuits in Automotive Design
Mr. V. Herterick, Vice President
Ucinite Div., United Carr Fastener Corp.

The Application of Organic Fibercord-Fiberglass Laminates
Mr. Norman W. Davis, Technical Director
Fiberglass Industries Inc.

Automatic Compression Molding
Stewart S. Helliwell, F. J. Stokes Co.

Moderator—E. J. Storfer, Chrysler Corp.

Panel on Foams

Polyurethane—Mr. Stanley Daniels, Asst. Technical Dir. Dryden Rubber Division, Sheller Manufacturing Corporation

Rubber—Dr. T. H. Rogers, Head, Airfoam Research Section Goodyear Tire and Rubber Company

Vinyl—Mr. Henry E. Allen, Vice President Elastomer Corporation

Friday Night Banquet Speaker

"Challenge to Plastics"—Hiram McCann, Editor Modern Plastics

Ladies are cordially invited. A ladies program is planned for both days. Saturday, September 28, will be recreation day at the St. Clair Country Club with golf, swimming, and so forth. This will be followed by a dinner dance. In addition to the above talks, we are planning a talk on automatic compression molding.

"Progress Through Plastics Engineering"—14th ANTEC Committee

Left to right—sitting: Erik Erickson, Finance; Mac Nichols, Publicity; Gordon Thayer, Speakers—Asst. Chairman; Mary Denny, Reception Secretary; Roy Smith, Prizes; Bill De Galan, Asst. Finance; Harry Haaxma, Program. Left to right—standing: Bill Goggin, Speakers; George Taylor, Member Registration; Jim Carelin, Sgt. at Arms; Don Skoog, Asst. Co-Registration; Harry McGowan, House; Mike Herzina, Banquet; Jack Morrison, Printing; Wm. Cruse, Reception (not shown); Ernest Widlund, Company Registration (not shown).

National Membership Committee

To All S.P.E. Members:

Dear Fellow Members:

Your Society needs more members! And it's your problem.

Your first reaction to this statement may be one of irritation, but it is your problem.

You want a better Society. You want a better Journal.

You want better Technical Conferences, both ANTEC and RETEC.

You want more Technical Books sponsored by your Society.

And we could continue to enumerate many more activities that you expect your Society to give you.

Your Society functions only on initiation fees and dues collected, and the cost of our operations has continued to rise as has everything else.

In order to do all the things that you have asked for, we must bring our membership list up to a total of 6,400 by January, 1958.

Membership in our Society is an honor to all in our industry. It is up to you to assist your Section's Membership Chairman by turning over to him the names of those men whom you feel are good prospective members, and whom you feel would benefit by membership in our organization.

Or better still get an application blank signed, sealed and deliver it to your Section's Membership Chairman.

Support your Society by actively going out after new members, so that your Society can better work for you.

Sincerely,
G. Palmer Humphrey,
Chairman, National
Membership Committee

Membership Committee Program

WEST COAST AREA

Roland K. Griffith, Chairman

Section	Section Chairman	Quota of New Members
Golden Gate	L. E. Faber	15
Pacific Northwest	D. W. Leuthold	10
Rocky Mountain	J. Ellis Chaney	5
Southern California	C. C. Zimmerman	55
South Texas	Robert R. Bench	15

MID-WEST AREA

Earl Wilson, Chairman

Central Indiana	L. I. Davis	25
Central Ohio	William Croll	15
Chicago	Earl Wilson	100
Cleveland-Akron	William Messina	75
Detroit	R. C. Oglesby	70
Kansas City	O. E. Kuhlman	20
Kentuckiana	J. C. White	15
Miami Valley	Paul L. Caldwell	30
Milwaukee	George Gray	20
Northern Indiana	Harry B. Bolson	15
St. Louis	W. P. Bussart	25
Toledo	D. R. Bowlin	15
Southeastern Ohio	Ray Baker	10
Upper Mid-West	Victor Wallestad	25

NEW ENGLAND AREA

Albert R. McIntyre, Chairman

Connecticut	Davis Mersey	30
Eastern New England	Gim P. Fong	45
Pioneer Valley	Henry W. Cox	30
Rhode Island and Southeastern Mass.	Morris Chafetz	30
Western New England	Larry Freeman	55

MID-ATLANTIC, CANADA, AND SOUTHERN STATES AREA

Edward L. Larkin, Jr., Chairman

Baltimore-Washington	Shelton Moore	30
Binghamton	J. E. Gwyn	15
Buffalo	Charles W. Kendall	25
Newark	Robert Fox	120
New York	Edward Larkin	135
Northwest Pennsylvania	J. C. Reib	20
Ontario	R. F. Harrison	35
Philadelphia	Samuel H. Greenwood	80
Pittsburgh	Neal J. Bricker	20
Quebec	R. A. Noble	20
Rochester	C. Burton Wing	20
Southern	R. W. Kruze	20

Industrial Literature

Department of Commerce Bulletins

Two reports of research for the Armed Forces on polymers, one dealing with synthesis of boron materials and the other with the best methods for determining dynamic mechanical properties, have been released for industry use through the Office of Technical Services, U. S. Department of Commerce.

Research on Boron Polymers; Part I. W. L. Ruigh and others, Rutgers University for Wright Air Development Center. Sept. 1956. 36 pages. $1. (Order PB 121718 from OTS, U. S. Department of Commerce, Washington 25.) This report covers one phase of a broad investigation into new hydrolytically stable polymers with exceptional fuel and oil resistance, and into preparation of materials for evaluation as hydraulic fluids and liquids. The volume deals primarily with the synthesis of alkyl and aryl boron dichlorides used as intermediates for the synthesis of boron substituted borazones and of tri-B-n-butyl-borazole. Also included is a study of the analysis of organo-boron compounds, with emphasis on development of a method for analysis of boron in borazoles. Preparation of B-beta-chlorovinylborazole also receives considerable attention, and the results indicate eventual solution of the problem of the preparation of boron polymers stable at high temperatures.

Survey of the Methods Used to Determine the Dynamic Mechanical Properties of Polymers. O. R. Abolafia, Picatinny Arsenal, U. S. Army. Sept. 1954. 35 pages. $1. (Order PB 121767 from OTS, U. S. Department of Commerce, Washington 25.) Reported in this volume are the results of a literature survey of the best methods to determine the dynamic mechanical behavior of polymers, or the mechanical properties of test materials under sinusoidal stress or strain. A general theoretical treatment of the information is achieved by classifying test methods for convenient discussion and comparison. The best techniques are grouped into three major divisions—attenuation methods, resonance methods, and direct stress-strain methods—and the divisions are subgrouped. The methods are discussed in regard to ease of operation, degree of accuracy and precision, and cost of instrumentation.

Polymer Evaluation Handbook. C. H. Adams and others, Monsanto Chemical Co., for Wright Air Development Center. Nov. 1956. 119 pages. $3. (Order PB 121870 from OTS, U. S. Department of Commerce, Washington 25.) This manual was intended to standardize polymer evaluation work done in the laboratories of Air Force contractors. A further use was to aid in training inexperienced technical personnel. The volume provides a system for obtaining a maximum amount of useful information on small quantities of experimental polymers. It also contains background information on principles of evaluation, properties and measurements and their significance, the nature and behavior of polymers, and physical characteristics of plastics in relation to each other and to other classes of materials. Interpretation concepts are discussed as they apply to appraisal of evaluation information and data.

Evaluation of Low-Dielectric Glass Fabric. F. Werren and B. G. Heebink, Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, for Wright Air Development Center. Oct. 1956. 24 pages. 75 cents. (Order PB 121859 from OTS, U. S. Department of Commerce, Washington 25.) A glass composition called 6-6-4 glass was recently developed which has better electrical properties than the standard "E" (for electrical) glass when used in glass-fabric-base plastic laminates. Fabric woven from yarns of the new glass fibers is called a low-dielectric glass fabric. In this research, comparative tests were run on laminates reinforced with fabric made with the new fibers and with the "E" fibers. Data showed that laminates made with the low-dielectric fabric were superior in electrical properties but inferior in strength and elastic properties.

Effect of Moisture Sorption on Weight and Dimensional Stability of Alkyd-Isocyanate Foam Core. V. C. Setterholm and E. W. Kuenzi, Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, for Wright Air Development Center. Sept. 1956. 34 pages. $1. (Order PB 121800 from OTS, U. S. Department of Commerce, Washington 25.) This research was undertaken to establish data on which to base predictions of any adverse effects of high-moisture conditions on alkyd-isocyanate foam cores in structural sandwich materials used in aircraft and missiles. Cores were immersed in water and exposed to high humidity for 60 days. Results indicated few differences between alkyd-isocyanate foams which had been foamed in blocks without facings and those foamed between two facings to make sandwich constructions. Exposure to high humidity caused increases in weight as high as 4.0 percent and dimensional increases of 0.7 percent.

Plastic Pipe

The United States Department of Commerce has issued a new commercial standard of Flexible Polyethylene Plastic Pipe. After careful review by the U. S. Bureau of Standards, and with the cooperation of the Polyethylene Pipe Standards Committee of The Society of the Plastics Industry, the revised CS 197 was developed and submitted to the industry for approval. This approval has now been obtained and the Revised Standard, known as CS 197-57, Flexible Polyethylene Plastic Pipe, is effective as of April 15, 1957.

Copies of CS 197-57 are available from the Superintendent of Documents, U. S. Government Printing Office, Washington 5, D. C. for 10c a copy. Copies of NSF's "A Study of Plastic Pipe for Potable Water Supply" are available from the Society of the Plastics Industry, 250 Park Avenue, New York 17, N. Y. for $1.00 a copy.

Small Metal Parts

In a new catalog received, Zierick Manufacturing Corp.—reputed to have the world's largest assortment of standard lugs, clips, terminals, and wire forms—describes their complete line of small metal parts. The standard parts shown are grouped according to most common use, and are available from stock.

Small Metal Parts Catalog No. 21 is available from Zierick Manufacturing Corp., Beechwood Avenue, New Rochelle, New York.

Consulting Services

The 16th edition of "CONSULTING SERVICES" 1957, published by the Association of Consulting Chemists and Chemical Engineers, Inc., is off the press. Revised and streamlined, 136 pages, 6 x 9, for easy handling, $1. per copy.

It offers a wealth of information and guidance for profitable conduct of business in all branches of industry, with directions for finding the right consultant to solve problems of manufacture, process improvements, research and development, plant designs and analytical and testing work in all its modern aspects.

NEWS of the industry

New Hull-Standard Plant

A new plant building at Hatboro, Pa., is nearing completion to house expanded manufacturing facilities of the Hull-Standard Corporation of Abington, Pa., manufacturers of the well-known Standard transfer and compression molding presses. The plant, on a five-acre tract 20 miles north of Philadelphia, was erected primarily to accommodate the growing backlog of orders for the firm's new Hull-Standard Model 99A Fully-Automatic Transfer Molding Press.

Fortiflex A500

Introduction of the second resin in its Fortiflex series was announced today by Celanese Corporation of America. This new polyolefin, designated Fortiflex A500, is now in commercial production in the company's Houston, Texas, plant. Warehouse stocks of Fortiflex A500 are now on hand for shipment from Newark, N.J.; Chicago; Los Angeles and Houston.

Injection Molding Machine

The fastest 6/8 ounce plastics injection molding machine on the market today is claimed by The Hydraulic Press Mfg. Co., A Division of Koehring Company, Mount Gilead, Ohio, in their new Model 200-H-6/8 which was recently offered to the plastics industry. At full clamp stroke with maximum tonnage, 720 cycles per hour are possible and as many as 900 cycles per hour with reduced stroke.

Auburn Changes Name

The directors of Auburn Button Works, Inc. of Auburn, New York, have approved changing that company's name to Auburn Plastics, Inc., effective September 1, 1957. Reason for the change, according to John H. Woodruff, President of the 81 year old firm, is the changing nature of Auburn's business.

Reed Prentice Moves

Reed Prentice Corp. branch office in Michigan is moving from Detroit to new quarters in Dearborn at 23705 Michigan Avenue.

Nylon 6 Plant

The Foster Grant Company of Leominster, Mass., has announced that its new plant for the production of Nylon 6 at Manchester, N. H. will begin operation around November 1.

Dielectric Seals

The Dynatherm Division of Guild Electronics announces the successful achievement of dielectric seals on polyurethane foam material. This development is the result of years of research, development, and Liaison work with several polyurethane manufacturers.

With the perfection of this new process, Dynatherm has initiated fabrication of production equipment which will be available to the trade at an early date.

Patents have been applied for to cover the new equipment and process. Several high ranking executives in the industry predict a polyurethane foam fabrication boom to match the expanding facilities of foam manufacturers. For further information on this new polyurethane foam heat sealing process, contact Dynatherm Division, Guild Electronics, 388 Broadway, New York 13, New York.

Polymeric Plasticizer

Processors of vinyl compounds for service under high-humidity conditions will find of special interest a polymeric plasticizer of high permanence for vinyl chloride polymers, recently introduced by Rohm & Haas Company. The product, Paraplex G-54, is of particular interest for applications where freedom from exudation on exposure to high humidity is essential.

High-Speed Machines

Designed for modern mass production in plastic molding operations, the world-famous Battenfeld high-speed injection molding machines offer fully automatic operation and many other advanced features.

Complete data and specifications for all Battenfeld models can be obtained by writing Molding Systems, Danielson, Connecticut.

Spencer Nylon Plant

Production of nylon has commenced at Spencer Chemical Company's new nylon plant at Henderson, Kentucky. The plant is producing nylon resins which will be used for a variety of molding and extrusion applications.

A pilot size nylon production unit also has begun operating at Henderson. The pilot unit will study ways to provide new and improved nylon resins.

Du Pont Fluorocarbon Resin

A new Du Pont fluorocarbon resin, expected to open up many electronic applications previously not attempted because of processing difficulties, was displayed publicly for the first time at the Western Electronics Show, August 20 to 23 at San Francisco.

The new material, called "Teflon" 100-X perfluorocarbon resin, approaches the outstanding heat resistance of "Teflon" tetrafluoroethylene resins but has a melt viscosity low enough to permit extrusion in standard equipment.

"Teflon" 100-X can be processed easily into jackets for coaxial and multiconductor cable, aircraft wiring, electrical hook-up wire, flexible and rigid printed circuits, and electronic components.

Paste Colors

A wide range of paste colors custom-tailored for liquid epoxy resins are now available from Color Division, Ferro Corporation, 4150 East 56 Street, Cleveland 5, Ohio. In a medium of 100% epoxy resin, the Ferro pastes provide excellent color dispersion, minimum effect on hardening time, minimum effect on end properties, and high color stability.

New Plastics Producer

Minneapolis-Honeywell Regulator Company has entered the field of plastics production.

The company has begun full-scale production of epoxy casting and potting compounds designed especially for use in the electronics industry.

Manufacturing operations are centered in the company's main plant in Minneapolis.

Meter-Mix

The Meter-Mix Corporation is now handling the design, manufacture and sale of the proportional metering, mixing and metered dispensing systems formerly supplied by Applied Engineering Associates of New York. The Meter-Mix Corporation will operate as a division of the Federal Machine Tool Company, manufacturers of precision equipment.

Mr. Marvin Schneider and Mr. Sol Schneider, both formerly affiliated with Applied Engineering, are now associated with Meter-Mix Corporation, coordinating technical liaison with customers requiring special process equipment studies.

Meter-Mix equipment is used for processing multi-component reactive liquid resin formulations such as the epoxies, polyurethanes, polyesters, polyamides and polysulfides. Ultra short pot-life mixes for production work are readily handled by this automatic proportional metering and mixing equipment without freeze-up or any clean out burden.

Polyflex Price Cut

An average price reduction of five per cent in its Polyflex 100 series, biaxially oriented polystyrene, has been announced by Plax Corp., Hartford, Conn. The reduction, effective immediately, is for thicknesses of from two to ten mils.

Cycolac Plant

A $10,000,000 chemical plant, representing Borg-Warner Corporation's first large scale investment in the plastics field, has gone into production, the corporation announced today.

The plant was constructed to manufacture a new heat-resistant plastic material known as Cycolac resin and will be operated by the corporation's Marbon Chemical Division.

Penn Plastics

As a result of a year-long expansion program, during which time sales volume doubled, Penn-Plastics Corp., Glenside, Pa., has installed the first unit of a planned series of fully automatic compression molding facilities.

The new facilities will be housed in the addition to the firm's plant which was completed early this year.

Fiberite 6100

Designated as Fiberite 6100 (Winona, Minnesota) the new compound equals the arc resistance of melamines and polyesters but eliminates the variable properties so often listed as deterrents for these latter two resins. Shelf life of Fiberite 6100 is exceptionally long. The material rates at over 5.0 izod impact and yet transfer or plunger molds easily. The material is an asbestos cord reinforced base. Important properties are: Molded shrinkage of .0004 inches per inch (for close tolerance molding and dimensional stability), flexural strength of 22,500 p.s.i. and tensile of 10,000 p.s.i. The material is in production. Contemplated use will be in applications where melamine and alkyd glass have been used. Other possibilities are switch bases, electrical connectors, heavy duty sockets, receptacles and insulators.

Further information can be obtained by contacting the Winona, Minnesota plant or Newark, Chicago or Los Angeles offices.

Hostalen Accepted

Hostalen, in all grades, has now been accepted under the Canadian Food and Drugs Act. This is the first polyethylene of the so-called "low pressure" type to receive such acceptance.

Data on the types and grades of Hostalen and details of processing and fabricating are available from Hoechst Chemicals Company, 200 Bates Road, Montreal, 9 Dwight Avenue, New Toronto.

Men In the News

ASTM Awards

Twelve technical leaders in the field of engineering materials, men who have rendered outstanding service to the American Society for Testing Materials, particularly in its technical committee work, were honored during the ASTM 60th Annual Meeting in Atlantic City, the week of June 16 when they receive Awards of Merit.

Citations for the awardees went to the following, who are also SPE members.

Albert George Henry Dietz, Professor of Building Engineering and Construction, Massachusetts Institute of Technology, in recognition of constructive leadership in the work of Committee C-19 on Structural Sandwich Constructions, and for notable contributions in Committee D-20 on Plastics, and to other ASTM activities.

Frank Walter Reinhart, Chief, Plastics Section, National Bureau of Standards, Washington, D. C., in recognition of productive service of broad scope in ASTM technical work, strong leadership including committee chairmanships, and outstanding contributions to the Society through research and standards covering especially plastics and adhesives.

Herbert A. Pohl

Dr. Herbert A. Pohl of the du Pont Experimental Station has been appointed to the staff of Princeton University as Lecturer and Research Associate under the Plastics Program. He will be Group Leader of the Dielectrics Research Section, and Lecturer in a graduate course in dielectric polymers.

Robert A. Paisley

Expansion of services in plastics in the State of Ohio, with the appointment of Richard A. Paisley as sales and application engineering representative for the Custom Molding Division, Chicago Molded Products Corporation, was announced recently.

George G. Stier

George G. Stier, vice president in charge of the Plastics Division of the Nopco Chemical Company, has completed 25 years of service with that company. At a party May 22 for long-service employees, Ralph Wechsler, Nopco's president, presented Mr. Stier with the traditional gold watch.

John W. Decker

John W. Decker, formerly Eastern District sales representative for Neilson Chemical Company, has joined the Synthane Corporation.

Philip B. Watson

The retirement of Philip B. Watson as plant manager of the Wallingford plant of American Cyanamid Company's Plastics and Resins Division has been announced. Mr. Watson will continue in the service of the American Cyanamid Company, acting in a consultant capacity in several areas, particularly in manufacturing, and industrial and public relations fields.

Daniel McC. Collette succeeds Mr. Watson as manager of the Wallingford operation.

James W. Simmons

H&R Industries, Nazareth, Pa. announce the recent appointment of James W. Simmons as Sales Manager of their operations. H&R are custom extruders and molders and produce heavy and light gauge polyethylene sheet. Mr. Simmons previously operated his own sales representatives organization in the industrial plastics field.

Paul P. Dickes

Paul P. Dickes has been named to the newly-created post of Controller by Penn-Plastics Corp., Glenside, Pa.

Prior to joining Penn-Plastics, Mr. Dickes was affiliated for five years with Stauffer, Bunn and Chambers, Philadelphia accounting firm in which he was a partner.

Edwin H. Ahlefeld

Farrel-Birmingham has appointed Edwin H. Ahlefeld, Jr., sales manager in charge of sales and engineering of processing machines for the rubber and plastics industries.

With the objective of improving customer service, the company has made a division of its products, placing in charge of each group, an executive responsible for both engineering and sales. This move has entailed no changes in the present sales and engineering management of individual product lines or the company's field organization.

Jerome T. Coe

Jerome T. Coe has been appointed manager of marketing for the Silicone Products Department, General Electric Company. He succeeds T. C. Ohart who has become general manager of General Electric's Insulating Materials Section.

William Demarest

William Demarest has joined the staff of the Manufacturing Chemists' Association as director.

Mr. Demarest comes to MCA from the National Association of Home Builders where he served as assistant director of the Construction Department & Research Institute.

AROUND THE WORLD

UNITED STATES

ELECTRICAL MANUFACTURING
July, 1957

Abstracter: Bennett Nathanson

Using Boolean Algebra to Design Static Control Circuits—*Staff Report*

Here is an actual case history of interest to all molders. Baker Brothers, Inc. manufacturers of automatic thermosetting compression presses, was one of the first original equipment manufacturers to apply static logic elements to control circuits of their own design. A step-by-step, actual design procedure is described for a 450 ton press which was set-up in an automobile factory and includes description of automatic feeding and removing of parts.

MATERIALS AND METHODS
June, 1957

Abstracter: Walter A. Gammel, Sr.

Selection and Design of Fluorocarbon Plastics — *Malcolm W. Riley*

This 20 page article is available as Material and Methods Manual No. 138—June, 1957. For the engineer contemplating the use of TFE (tetrafluoroethylene) or CFE (chlorotrifluoroethylene) it is "must" reading.

The article compares the specific properties of TFE (Teflon) with CFE (Kel-F, Fluorothene, and Genitron HL). Both offer excellent chemical resistance, high thermal stability, good electrical properties, and nonstick surfaces. The design and fabrication factors are also considered.

Numerous charts and graphs compare the effects of temperature, give typical physical and mechanical properties, state the effect of fundemental variables upon the properties. At room temperature for example, the mechanical strength of CFE is somewhat better than TFE, at elevated temperatures. The reverse is true, CFE having no strength beyond 390°F, and TFE iittle beyond 600°F.

Although fluorocarbons can be specified in the form of coatings, extrusions, laminates, or moldings, because of their nature the fabricating and forming techniques play a most important part in selecting the material to be used. Fluorocarbons can be machined and by new techniques even bonded. TFE can be welded to itself at about 700°F under appropriate pressure. As laminates the TFE and CFE provide the ultimate for printed circuits for critical requirements and service.

Coatings may be applied from dispersions or suspensions by brushing, dipping, or spraying followed by fusing at high temperatures. Coatings may be 4 mils typically. Wire insulation is made by slitting tape from sheets of TFE.

References are quite complete and are up-to-date.

Toxic Fume Exhaust System Uses Ceramics, Metals, Plastics — *Joseph H. Gettig*

Article is report on an award winning design. Imaginative way in which author used PVC headers for inlet water, for vapor condensate, condensate drain tube, ducting, stacks, and lining of steel body sections and polytetrafluoroethylene gaskets enabled him to achieve increased capacity, and reduced maintenance cost yet provide a more flexible system to exhaust toxic fumes emitted by a strong acid environment.

Which Organic Coating? — *Howard R. Rothenberg*

The author provides a quick working guide to help the engineer select the best coating or group of coatings that will meet the performance, decorative, and cost requirements of his product. Hints on narrowing the selections down to several or even one are offered as are suggestions for preparing a coating specification.

FRANCE

INDUSTRIE DES PLASTIQUES MODERNES
June, 1957

Abstracter: Hans Mayer

A. C. Polyethylene Waxes for Injection Molding — *A. Destable*

A.C. polyethylene wax is a pure polyethylene without any similarity to vegetable or mineral waxes. It is therefore absolutely neutral and perfectly compatible with the polyethylenes.

Addition of it to high pressure polyethylene compounds tends to improve the moldability and will tailor the material for the special application desired.

However, the addition must be dosed properly to achieve the proper fusion index for the mix. Besides the need of correct knowledge of the index of the molding material used, the size of the part to be molded will have to be considered to arrive at the proper percentage of wax to be added.

A.C. polyethylene wax is a good vehicle for coloring matters and its addition to the molding compound will not interfere in achieving even color distribution.

MATIERES PLASTIQUES
February, 1957

Abstracter: A. P. Daignault

The Mediterranean House, 1957

This article describes the thinking which led to the construction of this partly plastic house at Bandol on the French Riviera, and goes into considerable detail of the actual construction of the house. The walls made use of "Durisol", a cement block type of material containing wood fibers. The terraced asphalt roof was covered with a sheet of polyethylene which in turn was covered with a second layer of asphalt and a very thin coat of cement. The floors of the house are of PVC and resin bonded wood waste. Latex based paint (PVA) was used on the interior walls with styrene wall tile in the bathroom. Glass reinforced polyester panels were used on the interior doors.

Bibilography

A list of articles appearing in this publication during 1956 relative to the use of plastics in building.

The House of the **Atomic Era.**

This article (illustrated) describes the French "Circular" House, the Monsanto "House of the Future", and touches upon other futuristic ideas for housing.

Study of New Materials

This article lists new materials and plastic products and their producers.

Fabrication of Decorative laminates using Dapon Resins

Describes step by step the method used to make decorative laminates.

"Cinegraphie"

Describes two films; one, produced by the five French producers of vinyl resins is an informative film is directed primarily to the building trades showing vinyl applications. It is entitled "New Materials, New Homes". The second film, commissioned by Pechiney, describes the manufacture of PVC.

Material Studies

Describes materials, their uses, and method of application. The materials so described are:

1. Epoxy Based paints (Epikote)
2. Formica wall covering
3. Polyrey Laminates.
4. Floor covering (Rexon)
5. Polyester panels (Synplaxite)
6. Styrene Wall Tile (Mureco)
7. Polyisobutylene waterproofing material (Gertoit)
8. Polyester Panels (Heliotrex)
9. Surface Coatings (Filmeco and Polyrene)
10. Plastic Pipe (Tubofix)
11. Metal-vinyl laminates (Skinplate)

Review of the Technical Press.

Abstracts from other trade Journals.

Improvement in Shell Molding Through the Use of Resin Coated Sand.

This article discusses the advantages of using resin coated sands in shell molding. The methods and precautions to be taken in both the "hot mix" and "cold mix" methods of coating are listed.

Epoxy Resins; Chemistry, Properties, Structure, and Applications

Reprint from Revue des Produits Chimiques, Paris

This article is a resume of some of the papers presented at the symposium sponsored by the Plastics and High Polymer Section of the Society of the Chemical Industry at London University.

The following papers are reviewed:

"Some Characteristics of Systems Containing Epoxy Resins" by F. J. Allen and W. H. Hunter of Bakelite Ltd.

"Polyepoxy Resins: Their Chemical Reactions and Physical Properties" M. G. Ivinson, B. R. Howe, and F. M. Kartfen of British Resin Prod. Ltd.

"Mechanics of Condensation of Epoxy Resins" by W. Fisch, W. Hoffman, and J. Koskikallio of Ciba Ltd.

"Characteristics of Mixtures of Polyamide and Epoxy Resins" by D. E. Floyd, D. E. Peerman, and H. Wittcoff of General Mills, Inc.

"Some Observations on the Use of Glass Fibers for the Reinforcement of Epoxy Resins" by K. J. Brooffield of Fiberglass Ltd.

"Electrical Applications of Epoxy Resins especially in the Electronic Industry" by H. G. Manfield of Radar Research Establishment.

"Use of Epoxy Resins in Mixtures with Synthetic Rubber Bases" by T. F. Mika of Shell Development Co.

Exact Feeding of Injection Machines

A short article on the principles and mechanics of weight-feeding of injection presses.

TRED 50 and TRED 85, New Reinforcing Resins for Rubber.

A description of two new styrene resins now in pilot plant production by Monsanto Chemicals Ltd. which show excellent hardness, low specific weight, excellent flexure and abraision resistance, and good ageing characteristics. In addition to its being used in the footwear industry, other possible markets listed were in components for luggage, floor covering, and other industrial applications.

News of the World

BELGIAN CONGO: Opening of an extrusion plant by the Societe de Matieres Plastiques for fabrication of plastic and rubber pipe and other profiles.

FRANCE: Increasing Use of Plastics in construction, Rhodanite S molding powder with cellulose acetate base. Styrene monomer plant of Ethyl-Synthese in production at Mazingarbe.

GERMANY: "Hostaphan" film for safety glass, German Plastics Congress, April 10-11, 1957, Plastic laminates in packaging field, Flammability of plastic films.

GREAT BRITAIN: Polyethylene pipe for distribution of drinking water—problems of Flexikote, a new surface coating with asbestos base. Nylon cable. Stick-a-seal, a self adhering polyurethane foam, I-M Plastichrome, a new method of chrome plating plastic parts.

UNITED STATES: Production statistics for 1st Quarter 1957, Arco C 518, adhesive for polyurethane foam, Plastic laminates for store decoration. Acrylonitrile applications, Dispersable Organosols and Plastisols, Niatex Antistatic A.G.2 for textile applications, Licensing of W. R. Grace by Sequoia Process Co. for irradiation of polyethylene and other polymers, New filter for gasses under high pressures, Acetal Delrin, Toward more heat resistant plastics.

HOLLAND: International Plastics Exposition, Nov. 13-20, 1957, New urea plant, Agreement between A.K.U. and Spencer for production of Nylon 6 in U.S.

SWEDEN, SWITZERLAND, AND ROUMANIA: Resume of plastics in-industry in this country.

★

PLASTIQUES NOUVEAUTES

January, 1957

Abstracter: A. P. Daignault

Present and Future of Plastic Materials in Construction

This brochure which is primarily an advertising folder aimed at distributors, retailers, and users of plastic materials lists the good and bad qualities of the various plastics insofar as their usage in construction is concerned. It is based on previous U.S. press releases.

★

GERMANY

KUNSTSTOFFE

June, 1957

Abstracter: Anne Schwend

Vestolit S — Suspension Polyvinylchloride — *G. Wick and H. Koenig*

Maximum electrical properties, no water absorption, transparency, low viscosity upon processing within the flow zone and high thermal stability constitute demands which emulsion-type PVC could not meet. PVC produced by suspension polymerization and with a K-value variable between 55 and 80 upon choice, however, will cope with the problems presented. While suspension-type PVC with K-values between 55 and 70 is obtained in small balls and is meant for plasticizer-free processing, PVC with higher K-values offers better absorption of plasticizer through greater surfaces of the molecules agglomerated during polymerization into grape-like shapes. Fields of application for plasticizer-free suspension PVC and various forms of processing are discussed.

The Structure of Disacrylic Resins and Other Polymer Acroleins—*Rolf C. Schulz*

Acrolein, the simplest form of unsaturated aldehyde, called "propenal" according to the Geneva nomenclature, was tested as to whether or not a pure soluble polymer of acrolein could be obtained which would hold groups of aldehyde capable of reaction. If insoluble products would be produced, the reason for their insolubility should be stated. Investigations resulted in the following statements:

a. With the help of different typical polymerization catalyzers such as benzoyl peroxide, redox systems and aluminum chloride, acrolein may be stimulated to polymerize.

b. Properties of polymer acroleins depend to a large extent on conditions during polymerization. Soluble, meltable, insoluble and unmeltable products are obtained. The properties of polyacrolein obtained by redox polymerization resemble most closely to those of "disacrylic" polymers.

c. By reaction of disacrylic and redox polymers with typical carbonylic reagents a number of derivatives is obtained. The presence of aldehyde functions in such polymer acroleins is proved thereby.

d. The degree of reaction depends on the reagents used and test conditions. A maximum of 70 to 75 mol-% is obtained with oxims and phenyl hydrazones.

e. Depending on the chemical structure of polyacrolein derivatives, they are soluble in various organic solvents and even in water, quite contrary to the insolubility of the base products.

f. Organically soluble polyacrolein derivatives can be fractionated. Osmotic tests showed that disacrylic and redox polymers represent macromolecular materials.

7th German Plastics Convention in 1957

Brief on this successful convention in April 1957 held in Bad Pyrmont which was frequented by 1596 guests. Most of the 20 papers presented will be reprinted or abstracted in the August edition of Kunststoffe.

Silicone caoutchouc as Processing Aid for Glassfibre-reinforced Polyester Resins — *F. Schaefer*

A resume on the best and most useful application of silicone caoutchouc as mold release agent, mold material for castings, vacuum and pressure bag molding as well as extrusion and contact molding.

Pre-Forming of Glassfibre-Reinforced Plastics — *H. Hagen*

A survey on pre-forming methods, in particular those developed in the United States and discussed at the 12th Technical Conference of SPI and the 13th Annual National Technical Conference of SPE in January 1957. Further, a new pre-form-machine by Aust & Schuettler of Germany is described which permits simultaneous spraying of glass-fibres and polyester resins. This machine is equipped with a control station for setting feed quantities as well as feeding time for both resins and rovings. The aggregate may be wheeled to the place of application, for instance when used for sound absorbing coatings on walls.

PVC Pipelines with Screw Joints—*H. Jungnickel*

Discussion of PVC screw joints as applied by U.S. firms in South Africa for joining PVC pipelines. Such joints which have been in use for about 18 months only have not given rise to any complaints so far. The German Standards Committee has warned against their use, but before a final refusal is worded it should be watched how they stand rough conditions.

Organic Glass Strip Lights—*W. Bauer*

Possibilities offered by the ability of organic glass, preferably methacrylic, to invisibly transmit parallel light rays with an angle of incidence of less than 48° and totally reflect them through polished surfaces, or transmit such light rays with an angle of incidence of more than 48° to a point, even following a curve, where the polished surface is interrupted by ground surfaces or edges and reflecting them there, are discussed in particular with a view to modern room lighting.

New Possibilities for Polyethylene

Reprint from Modern Plastics, December 1956, showing the utilization of low pressure polyethylene monofilaments substituting polyamides in certain cases.

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KUNSTSTOFF-RUNDSCHAU
May, 1957
Abstracter: Leo Fischer

Effect of Various Monomers on the Characteristics of Unsaturated Polyesters — *Edith Behnke*

This article is a valuable discussion of the effect of twenty-one different monomers on the characteristics of unsaturated polyesters. The use of styrene is, of course, well known and possibilities of room temperature cures with it. The fact that oxygen interferes with polymerization and thus prevents a styrene polyester to be used as lacquer is, of course, a disadvantage. With vinyl toluol the water absorption is much less, dialectic strength is improved, shrinkage during cure is reduced, curing time is shortened, no blisters are formed during high temperatures and viscosities during cure remain higher.

A divinyl benzine polyester is more reactive than styrene; the saturation is greater and thus heat resistance and chemical resistance are improved. This is especially true of the ketones and chlorinated monomers. Vinyl acetate and isopropenyl acetate have no value. Vinyl-butyl ether gives a clear polymer which compares favorably with the styrene polyesters. Vinyl-2-chlorethyl ether has value as a fire retardent. A table is included giving the name of the monomer, the structural formula and various physical data as well as manufacturers.

New Applications of Epoxy Resins—*K. Meyerhans*

This article presents a paper read at the "Plastteknik 1956" conference in October, 1956. The discussion is concerned with the special qualities of epoxies and the many applications possible. Numerous articles are illustrated and their production described as well as their physical characteristics.

Application of Neoprene Adhesive in The Building Industry—*C. Baillod de la Juilliere*

One of the chief advantages of neoprene as an adhesive in the building industry is that only a few seconds of pressure contact is necessary. Neoprene adhesives are waterproof, elastic, shock resistant and do not age. They can be used indoors and outdoors. Addition of isocyanates improves the adhesive qualities and general durability of neoprenes.

★

DER PLASTVERARBEITER
May, 1957
Abstracter: Leo Fischer

Experiences Encountered in Using Unsaturated Polyesters as Casting Resins in Elastic Molds — *Schirmer*

Polyesters, cast without glass fibres, but with fillers, may be cast in flexible molds and produce valuable articles. Mentioned as mold materials are plastisols, gelatines, natural rubber, and silicon rubber. A material called "Formalose", a proprietary product, is also described. This product is melted and poured over the mold and cooled. Although better than most other flexible materials it does not last for more than thirty to forty castings. Melting of highly plasticized PVC is mentioned but separaters have to be used so as not to extract the plasticizers. Gelatine needs no separater and has a fair durability—about thirty castings, provided cold cure and low exotherm is possible. Natural latex makes a good mold material but has to be heavily coated not to act as a surface inhibitor. Silicon rubber seems to be the best of all but must also be coated each time it is used and the surface stands up for thirty to forty casts at the most. Heat cure is, however, possible.

Technical Considerations in the Construction of High Frequency Generators for Electronic Heating—*J. Linke*

This article discusses the problems and techniques involved in constructing high frequency generators. It concludes with an analysis suggesting that since high frequency applications are still limited due to equipment deficiencies a combination of high frequency and infra red can often be very useful. The method of this application is described.

When to Compression Mold Upside Down—*Heinrich Spies*

A method of molding complex forms with undercuts or forms with metallic inserts is described and illustrated. The male part of the mold is on the bottom and a preform the size of the mold is simply laid on. The upper part of the mold, which is the cavity, closes down. When the mold opens the sides of the cavity slightly spread to release the piece from the undercut.

Practical Rules in Plastic Technique — *H. Gut*

This article gives tables and various formulae for calculating the size, weight and wall thickness required in estimating costs for various shaped objects in materials of varied specific gravity. Cubical, hexagonal and spherical shapes are discussed as well as tubes and pipes of various shapes.

ITALY

POLIPLASTI

March-April 1957

Abstracter: Alfred L. Alk

Application of Differential Thermal Analysis to the Study of Plastics — *Giorgio Galvan*

A detailed discussion of Differential Thermal Analysis and its techniques. The author relates the techniques to the study of several plastics materials and indicates how its use can replace more well known methods of analysis.

Plastics in Wearing Apparel

A brief illustrated presentation of manufactured articles and the plastics from which they are prepared.

General Classification of Foams — *Walter Brenner*

Flexible, rigid, preexpanded, self-expanding are the foams available on today's market. They may be subclassified as open or closed cell.

Flexible Foams: Urethane type: These are formed from the co-reaction of an isocyanate, water and one of several other materials such as polyesters, glycol ethers or oils, in proportions which give the required properties. They have great physical and chemical resistance. The flexible urethanes, produced largely in Germany, with U. S. interest growing, are used for cushions, packaging, upholstry and clothing. They show, up to the present time, poor aging qualities. The semi-rigid urethanes are not so strong and are used mainly for thermal insulation. They are produced by mixing at ambient temperature, by hand or with special quick-acting equipment. Sometimes the product is baked, other times air dried. A prepolymerized form requiring only addition of catalyst is particularly popular in the U. S. because of its lower exotherm.

Vinyl type: Flexible, rigid and semi-rigid vinyls are noted for their resistance to ozone, humidity, mold and rot and for their good chemical resistance. Most are self-extinguishing. Production is by addition of foaming agents which decompose on heating to form gasses or by a patented process of dissolving carbon dioxide gas in the liquid resin and allowing the gas to expand.

Polyethylene type: Polyethylene foam has all the properties of the solid form of the resin. It is produced chemically by means of blowing agents.

Rigid Foams for Expansion at Will:

Polystyrene type: A light foam resistant to passage of heat, with low moisture absorption and resistant to fungus growth. It is formed from beads which are heated with steam or hot air causing them to expand. There are three methods of production. Direct injection of steam into the mold cavity; heating the mold with steam; or heating the mold with hot air. Polystyrene foam may be easily adhered to itself or to other materials and may be shaped with ordinary wood working tools.

Urethane type: Already mentioned under flexible and semi-rigid, its properties depend largely on the density. In general it has good strength, exceptional adhesion to wood, painted metal, etc., good moisture resistance and thermal stability. It is an excellent electrical insulator. It is used as an anti-shock and anti-vibration material in airplanes, for electrical insulation and for sandwich construction.

Phenolic type: This is a generally fragile foam whose properties depend on the base resin. Its water absorption may be reduced by coating the surface. It is a good thermal and acoustic insulation, has the good chemical resistance of phenolics and may be used up to 105°C in intermittant service. Its principal uses are as materials for flotation, thermal insulation, packaging and construction. It is produced from phenolic syrup by means of chemical agents which promote an expansion greater than 300 times.

Sintactic Foams: These are based on nitrogen filled microbaloons which may be supported by a resinous carrier.

Silicone types: A foam with a 370°C distortion point. It has good resistance to thermal shock but is friable. Various types may be expanded in place or pre-expanded in block form. Possible uses are for thermal and acoustic insulation for missiles, supersonic planes and special electronic devices.

Preexpanded Rigid Material:

Polystyrene type: Available in the form of blocks of various dimensions. Its major disadvantage is flammability. Its major uses are thermal insulation for refrigerated containers of all kinds, for marine flotation and for manufacture of ornaments.

Cellulose Acetate type: It is produced by evaporating a superheated solvent from a continuous extrusion process. It has good thermal stability and resistance. It is currently employed mainly as a core for aircraft and marine laminates.

Epoxy type: Available on the market in a variety of densities or as a syrup to be foamed in place. It is used as a core for laminates and for potting electrical components.

Urea Formaldehyde type: This has a low thermal conductivity and can be used at 50°C for extended periods. It finds its major use in refrigeration.

Developments and Achievements in Radiochemical Polymerization —

(Please turn to page 69)

For a clearer understanding of the fundamental nature of plastics

READ

ENGINEERING PROPERTIES AND APPLICATIONS OF PLASTICS

By GILBERT FORD KINNEY, Professor of Chemical Engineering, U.S. Naval Postgraduate School, Monterey, California.

If you work with plastics, this lucid, comprehensive description of the newest of the engineering materials, will furnish you with the necessary background information for their proper utilization and specification. The various plastics are described separately, more or less in the order of increasing complexity. The unified treatment permits the principles, concepts, and terminology to be established in the simpler cases, and utilized in treatment of the more complex materials.

Professor Kinney's book contains a tremendous amount of subject matter, simply and conveniently organized by the selection of pertinent material to illustrate principles. Separate chapters describe methods for fabrication, as well as the mechanical, electrical, optical, and thermal properties of these materials. An abbreviated survey of the type reactions of organic chemistry is also provided.

Contents Include: The General Nature of Plastics. Polyethylene. Polyvinyl Chloride. Polystyrene. The Acrylic Plastics. Other Vinyl-Type Plastics. The Cellulose Plastics. Phenolic Plastics. The Amino Plastics. Polyesters, Polyamides, and Epoxies. Silicones. The Rubbers. Molding Methods. Engineering Properties. Thermal Properties. Optical Properties. Electrical Properties. Chemistry of Plastics. Tables.

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SECTION NEWS

Edited by
Charles P. O'Donnell
Monsanto Chemical Co.
Springfield, Massachusetts

Cleveland-Akron

Rain Washes Out Golf Day

Robert L. Larsen

Water Polo would have been in order for June 28, the day scheduled for the annual Golf Outing for the Cleveland-Akron, SPE, Section. It seemed that Hurricane 'Audrey' had not done enough damage in the South, so she emptied her skirts of more than three inches of rain during the day, beginning about the time the first foursome was preparing to tee-off. On the rolling grounds of the Aurora Country Club, this left water of varying depths—so what was to be done but to see how the Rules of Hoyle came into being. By late evening, after the surplus of food had satisfied the appetite of all, and prizes were distributed even new rules came into being.

But let us not forget those of the Golf Committee who tried to make it one of those real enjoyable days that we had all been looking forward to. C. W. (Chuck) Helmrich, Jr., Chairman, and his committee did their best to make it enjoyable.

So next year is another year and it will be bigger than ever.

Our Program Committee reports that they have an interesting program worked out up into February of next year, and even went so far as to provide an interesting meeting for June 10th, which was held at the Spanish Tavern, Brecksville, Ohio and attended by about 80 members and guests.

This was of Double Feature type, with two speakers.

Our first speaker was Mr. T. A. Rogers, of the Goodyear Tire and Rubber Co., who spoke on the subject —"Elastomer Cellular Materials". Mr. Rogers' paper gave the growth of Elastomer and Plastic Foams over the past twenty years; their uses and potential and chemical properties of the various types.

Mr. J. E. Stokes, Bakelite Co., was our second speaker and his topic was: Progress and Design in Reinforced Plastics. After his discussion on materials and uses for Reinforced Plastics, added information was made possible by the showing of a film on subject matter.

Important dates coming up are as follows:

August 26th (Tentative) Clam Bake. Sept. 9th—Regular Meeting—Rotational Casting. October 17th—Special—Regional Symposium—Polyethyelene.

Golden Gate

Lenkurt Tour

William Hill

A tour of the Lenkurt Electric Co. plant, San Mateo, was the feature of the June 27 meeting of the Golden Gate chapter of the Society of Plastic Engineers.

Lenkurt is a manufacturer of electronic communications equipment for use by the Bell Telephone Co., railroad communications systems, other industrial communications organizations and the military.

At the meeting, A. Scot Robertson briefly outlined and described Lenkurt's products and company's processes. Eugene Brown and Herbert Shores acted as plant guides for the SPE-SPI.

The tour concerned itself with present plastics applications which include: epoxy encapsulation; plastic sheathing of fragile parts; and the use of phenolic boards and parts.

N.W. Pennsylvania

Plastic Foam Material

A. P. Wagner

The Northwest Pennsylvania Section held their June meeting at the Summit Hotel in Erie, Pennsylvania, Thursday, June 20th, 1957. The subject for the evening was "Plastic Foam Material".

Mr. Richard Gromachi, Market Development Representative of the Research and Engineering Department of Wyandotte Chemical Corporation, Wyandotte, Michigan, was the first speaker.

"Rick" presented a most interesting talk on the past, present, and future Polyurethane Foams, and with the help of some most interesting samples, he reviewed out the versatility and the extremely wide range of potential applications in the Polyurethane field.

He pointed out the impact on the industry by the Polyether resins since they are much lower in cost and produce a more resilient foam than the commonly used Polyester resins. This could open up a whole new potential to the industry.

The second half of this double-barrel program was ably handled by Mr. Edwin Edberg. "Ed" is manager of the Dylite Expandable Styrene branch of the Market Development Section of Koppers Company, Inc.

With the aid of very well prepared slides and samples, he thoroughly covered the material specifications, processes used in manufacture and applications of expandable styrene.

A survey of those attending indicated unanimous approval of the program and both speakers did such a fine job that we in the Erie area intend to invite them back for a repeat performance next spring.

Necrology

Deceased: J. L. Kane, member of Newark Section.

T. C. Campbell, May 21, member of New York Section.

Peter Doraik, June 6, struck by a car, former member of Chicago Section.

Meeting Dates Changed

Meeting Dates Changed

Kansas City	— Will meet on the Wednesday following the second Tuesday of each month.
Rocky Mountain	— Will meet on the Thursday following the second Tuesday of each month.
St. Louis	— Will meet on the second Tuesday of each month.

Chicago

Simmons to Speak at Oct. 13 Meeting

By Joseph J. Schmidt

River Forest Country Club was the scene on August 10th of the third and final golf outing of 1957 sponsored by Chicago Section. Attendance totaled 112 members and guests. Jay Gaines, Catalin Corporation, was low gross winner with 77; Earl Keown, Felsenthal Company, swept low net honors with 79-11 — 68. Members congratulated Bob Reynolds, Artag Plastics, for his work as Golf Chairman succeeding Russ Hanna, who has been transferred east by Hercules Powder Company.

Chicago Section Board of Directors elected Gib Baccash, Lind Plastics, as Vice-President to succeed Hanna in this post. Lee Hunter, Koppers Company, returns to the board as a member.

National President Peter W. Simmons will be a speaker at Chicago Section's meeting on Monday, October 13th, to be held in Headquarters, Western Society of Engineers.

ASTM D-20 To Meet

The next meeting of Committee D-20 A.S.T.M. will be held at Virginia Beach, Va., November 20-22, 1957.

Committee officers are:

Chairman: F. W. Reinhart, National Bureau of Standards, Washington, D. C.

Vice Chmn.: A. C. Webber, E. I. duPont de Nemour & Co., Wilmington; and A. G. H. Dietz, MIT, Cambridge, Mass.

Secretaries: J. B. DeCoste, Bell Telephone Labs., Murray Hill, N. J.; R. H. Carey, Bakelite Co., Bound Brook, N. J.; and B. L. Lewis, Tinius Olsen Testing Machine Co., Willow Grove, Pa.

Irvington Price Guide

A new, 16-page pricing guide for Irvington plastic and coated electrical tubings was made available nationally this month by Irvington Division, Minnesota Mining and Manufacturing Co., Dept. D7-208, 6 Argyle Terrace, Irvington, N.J.

Jas. R. Davidson Leaves SPE to Join Capac Industries

Mr. J. V. Kielb, President of Capac Industries, Inc., Capac, Michigan, announced the appointment of Jas. R. Davidson to Vice President and General Sales Manager of Capac.

Mr. Kielb stated that they had made this appointment in order to extend Capac's expansion. The Company has decided to diversify further into the fields of extruding, forming, molding, fabricating and finishing of thermosetting and thermoplastics products.

Mr. Davidson comes to Capac from his post as Executive Secretary of the Society of Plastics Engineers, Inc. Prior to this he had been with Hoosier Cardinal Corporation for eleven years where he had served as Sales Manager for the Plastics Division.

Davidson attended the University of Illinois and served on the engineering staff of Consolidated Vulte Aircraft for five years before going into the plastics industry.

Extreme Strength . . . .

(Continued from page 28)

Black polyethylene 3 Mil-Mylar .5 Mil reinforced material was exposed in Florida from one to two summer seasons. This material was mounted so that one end of a metal can, having a capacity of five to six gallons, was completely closed by the material. This was done to determine the effect of contact with corroding metal and the effect of daily water condensation on the interior surface. The exposed black polyethylene surface was dulled by ultraviolet light but the samples were substantially unaffected.

Materials which have been exposed in Florida and have failed include reinforced clear polyethylene, cellulose acetate butyrate, aluminized Mylar, and blue pigmented polyethylene.

Accelerated rapid-load tests were made using parachutes of Mylar to Mylar reinforced material. These tests produced no failure in seams or material. This reinforced material was tested by making a 29-inch model parachute of 50-50 gauge film reinforced with a grid having the fibers 7/16" apart. The parachute was dropped from the top of a tower of 80 ft. height to observe the opening characteristic of the parachute. This also tested the strength of the material and the seams. The parachute opened in every case; no rupture or tear of the material or seams was observed.

Another parachute was enclosed in a weighted mailing tube. The shroud lines of the parachute were attached to a 2" x 4" piece of wood projecting upward from the rear of a truck. The parachute was opened by throwing the weighted mailing tube from the back of the truck. The parachute opened perfectly in every case. No failures nor tears at the seams or in the material were observed in any instance. One problem did arise from this test. The impact of the parachute opening was so great that it caused the 2" x 4" board to snap.

The parachute withstood severe bumping against the pavement and the gravel shoulder of the road. No major injuries occurred to the material. No tears nor rips were observed in the parachute in the material nor in the seams.

The parachute was allowed to drag against the surface of the road. As a result, the material picked up or bumped into a number of small rocks. These were part of the surface of the gravel road on which the tests were conducted. The parachute material was perforated in several places by these rocks. Subsequent openings of the parachute did not cause tears to propagate from these holes.

It may also be possible to use the aluminized Mylar reinforced material for stratosphere balloons. This may be a very good use since the aluminized material could be tracked by radar. The material would also be capable of carrying the heavy equipment attached to these meteorological balloons. If a tear started in the material, the balloon and instruments would be gradually lowered to the ground. At the present time, if a tear starts in the balloon, the balloon deflates and the equipment falls to the ground and is destroyed.

Extreme strength fabrics may also be used in air supported buildings. The plans for our first building have now been completed and construction will soon be begun. ★

Flow Properties . . .

(Continued from page 35)

be used together with small radial clearances. Figure 6 shows the effect of radial clearance on the temperature uniformity of a fluid having an apparent viscosity of 10^7 poise and a thermal conductivity of 10^{-4} cal/cm-sec-deg.

Heat generation in a cone-and-plate viscometer can be a more difficult problem than in a concentric cylinder instrument. Although there is a uniform rate of heat generation (per unit volume of fluid), the thickness of the fluid layer varies from zero at the center to a maximum at the edge. Since the heat generated in the thicker portions of the fluid will be conducted out through a longer path, the temperature rise in the fluid will be a function of distance from the axis of rotation. At low shear rates or with fluids having low apparent viscosities this effect will be negligible, but with materials having high apparent viscosities (above about 10^7 (poise) temperature gradients in the fluid may present serious difficulties.

Summary and Conclusions

The major requirements for a viscometer to be used with molten thermoplastics are summarized below. (1). The data obtained from the instrument should reflect **only** the nature of the material being tested and should not be a complex function of material and instrument constants. In other words, the viscometer should yield data which can be converted into true flow curves. (2). A wide variety of materials is handled in plastics processing equipment over a wide range of shear rates. To be useful to the plastics engineer, then, a melt viscometer should be capable of handling a wide range of viscosities, from 10^3 to 10^7 poise or higher, over a wide range of shear rates, from 1 to about 10^3 sec^{-1}. (3). In many plastics processing applications it is important to know whether or not the flow properties of the melt are time dependent. Therefore, it is desirable that a melt viscometer be able to detect and measure long time effects under steady flow conditions.

At the present time it appears that no single melt viscometer exists which meets all of the above requirements. For the reasons discussed previously, it appears unlikely that an extrusion type viscometer can be designed which will meet requirement (3). Rotational viscometers offer the most promise but extreme care must be taken in their design to eliminate errors caused by internal heat generation in the fluid. In addition, the purely mechanical problem of loading and unloading the instrument with the sample presents a real challenge to the designer.

Acknowledgment

This study represents part of a research program in plastics processing at the Johns Hopkins University which is supported by a grant from the Plastics Division of the Monsanto Chemical Company.

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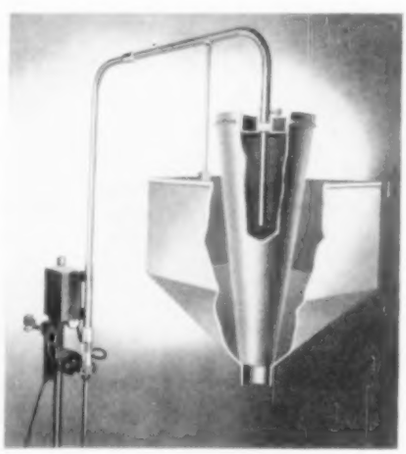

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Synthetic Fibers . . .

(Continued from page 26)

TABLE 1

Insulation Resistance Values for Reinforced Polyester Resins after Conditioning at 95° F. and 90° R.H. Standard ASTM D257-49T Method (Comparison Method using Galvanometer—90 Volt Source) Reading Given in Megohms

Reinforcement Description	Initial Readings (1) Average	After 4 Days Average	After 29 Days Minimum	After 29 Days Average
Orlon	oo	oo	1.1×10^5	1.1×10^5
Dacron	oo	oo	1.1×10^5	1.1×10^5
Nylon	oo	15,000	1,000	2,600

(1) *Initial Readings taken after conditioning 24 hours at 75°F and 50% R.H. Readings marked oo indicate a resistance greater than 1.3×10^6 megohms. Average based on five readings in every case.*

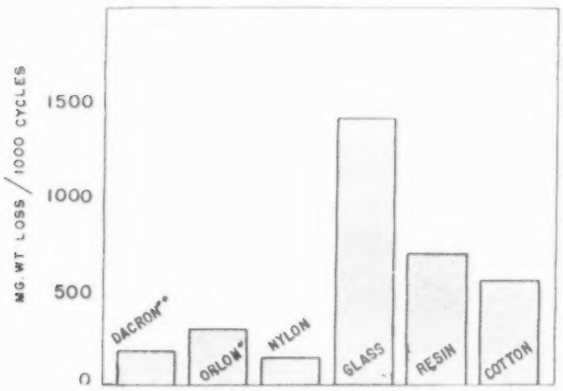
The electrical properties of synthetic fiber reinforced plastics have led to the development of several commercial products. Phenolic resins reinforced with nylon and diallyl phthalate, and epoxy resins reinforced with Orlon are being used for critical applications involving humid conditions.

The dielectric behavior of polyester resins reinforced with Dacron is responsible for field evaluations in radomes and other high frequency components. Laminates of Dacron and Orlon are also being examined for high performance printed circuits to take advantage of their insulation resistance and moisture insensitivity.

Laminates reinforced with synthetic fibers possess excellent resistance to abrasion. Test data may be seen in Figure 7 showing comparative weight losses of various laminates after 1,000 cycles on a Taber Abraser. The laminates of nylon, Dacron and Orlon lost 150, 200, and 300 milligrams, respectively. Glass and cellulosic fiber reinforced laminates and unreinforced resin lost from 750 to 1500 milligrams of weight.

(Please turn to page 68)

Figure 7. Abrasion resistance of reinforced polyester resins.



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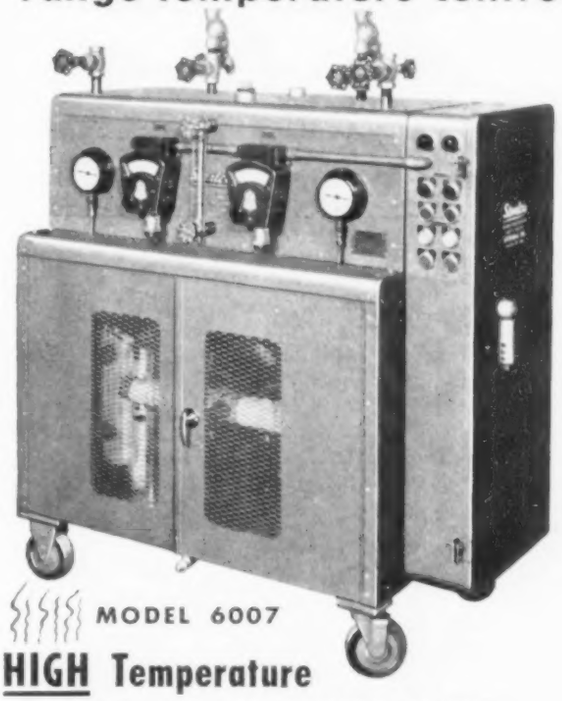

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Radiation Protection . . .

(Continued from page 23)

head and upper body through the air tunnel. Other improvements were also made in suit design to accommodate the specific needs of the job and to improve comfort and efficiency of the worker. In the improved models the bottom of the tunnel is also swept forward in a line with the feet. This creates a cab of transparent plastic in which the worker can stand and turn around freely. From this position entering of the suit becomes reduced to stepping into the legs which are attached to the ledge in the front of the suit. The seam at the back is the closing point of an air pressure curtain. Air supplied through the ventilation tunnel is permitted to inflate the suit to the worker's satisfaction by controlling the size of the opening in the curtain through which the air escapes back into the tunnel opening. Since such suits may be used in areas of varying air differential, the use of this device permits maximum maneuverability of the suit. It also prevents worker claustrophobia which is not uncommon when insufficient inflation of the suit exists. In recent models this philosophy of combined safety, efficiency and comfort included numerous convenience items.

It is possible to get in and out quickly permitting use of the suit where radiation time limits make it necessary to conserve the worker's time. Pockets on the inside of the suit increase the workers efficiency for handling small items.

As the use for flexible plastics in the atomic energy field becomes more established and widespread, the demand for improvements in qualities of the plastic will present an increasing challange. We must be looking forward to the time when it is possible to apply flexible plastics to contamination control with assurance that the seams will not tear and that the plastic will resist puncture to a degree many times that of its current ability. We must learn to combine conflicting but desirable characteristics of varying plastics without sacrificing other needed qualities. A present dilemma is that transparent cast vinyl plastics stick when rubbed against each other. This tendency of cohesion needs to be reduced while still retaining the complete transparency of present film. New films are being developed which have tremendous strength but it is not always possible to seal them by electronic methods. Further use of laminations may be the answer to some of these problems thus permitting the excellent quality of two different films to reinforce each other without sacrificing the quality of either.

Related Developments

In discussing the application of flexible plastics for contamination control we should not lose sight of several related developments to which flexible plastics may be put. One such miscellaneous use may be seen in the use of an aqueous dispersion of plastic which may readily be spread over a contaminated area for fixing the radioactive particles to the surface. A film which has been spread over a floor area is easily peeled from the surface, removing with it the contamination which would otherwise have been difficult to remove or confine. Another typical field for application of flexible plastics for control of contamination is the use of small disposable hoods for minor or isolated jobs in support of maintenance operations or laboratory work. An example of such odd-ball applications is a six-armed enclosure, resembling a caterpillar. It is used for confining dust created by a cutting wheel. Such applications are of particular advantage in removal of obsolete equipment where contamination control is vital but where more elaborate or permament enclosures cannot be economically justified. Such temporary enclosures are also of advantage on so called "one shot" operations. An example is a plastic cover being used to confine radioactive dust during the decontamination of a vessel interior. A simple hood of flexible plastic held out by a crude wooden framework can be used in transferring ingredients from the container below it to a vessel within the larger enclosure. It is quickly made upon short notice.

From the long range view it is probable that the simple plastic tube will be the greatest single application of flexible plastics for contamination control. Actually the role of the simple plastic tube in contamination control has barely begun. It is likely to make even greater contributions to contamination control outside the atomic energy field than it has within it. ★ ★

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book reviews

QUALITY CONTROL AND STATISTICAL METHODS

Edward M. Schrock, Second Edition, 230 pages. $6.75. Published by Reinhold Publishing Co.

As stated in the preface of the First Edition—"The purpose of this book is to present as clearly as possible, as briefly as practicable, and yet adequately, the most generally useful modern techniques of quality control and statistical methods as applied to industrial problems of product quality." The author accomplished this objective by limiting his primary subject matter to the straight forward techniques of quality control—namely, sampling procedures and control charts.

The First Edition contained no information on how to organize and activate a quality control program. The first two chapters of the Second Edition are concerned with this problem and are effective as a means of introducing the reader to the basic subject of quality control. The importance of organization and management, relative to the size of the quality control program, is discussed along with the bearing this can have on sustained quality control programs.

An introductory chapter on the analysis of variance has been included in the Second Edition. The chapter is sufficient, though barely so, to give the reader an insight into the subject.

While the Second Edition is improved over the initial volume, the strength and merit of this book still lies in the simplicity of treatment and the purposely limited scope of subject matter selected to be of prime interest to those interested in product quality control. This book is well suited for those who wish to get underway in the field of statistical quality control on their own power. The quality control engineer or supervisor would also find the book a good text for course work with shop personnel.

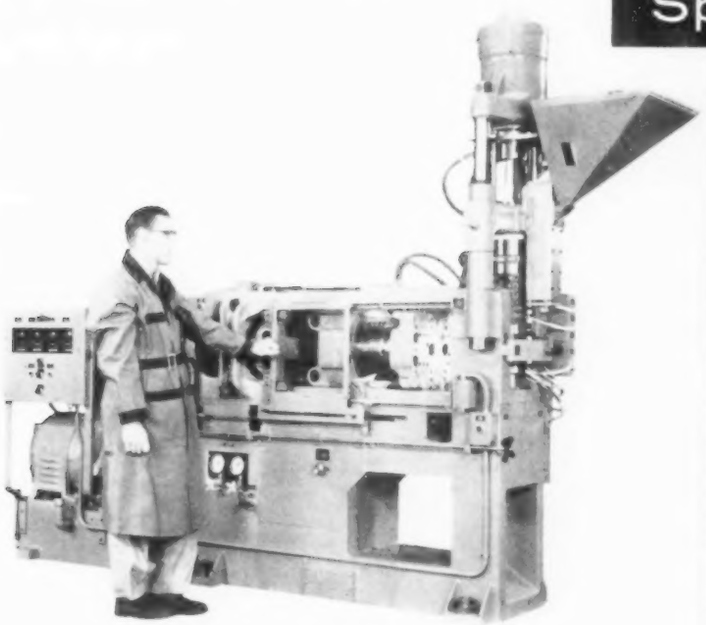
L. M. Dehing

BRITISH PLASTICS YEAR BOOK 1957. A Classified Guide to the Plastics Industry. 27th Edition. Published on 1st March 1957 by Illiffe and Sons Ltd. Price 42s. net. (postage 1s. 9d.) Size 9¼" x 6¼". 716 pages.

British Plastics Year Book remains the only classified guide to the products and manufacturers in the plastics industry and this year it has been modernised in appearance, being bound in a durable and handsome plastics case.

This thoroughly revised 27th edition is divided as before into nine sections, three of which are devoted to classified lists of manufacturers and suppliers of materials, finished products, and equipment. Another section contains the world's largest list of trade and proprietary names connected with the industry, and covers materials as well as finished products. Each trade name is followed by a definition of the product, the manufacturer concerned, and the country of origin when the manu

Specifications of...



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Book Reviews . . .

(Continued from page 67)

facturer is overseas. A glossary of technical terms used in plastics is again included in this section.

The names and addresses of nearly 4,000 firms associated with plastics are grouped into countries in the names and addresses section. In addition, the Who's Who section lists names and positions of prominent people actively engaged in the industry in Great Britain.

One of the most important features of the Year Book is the annual review of plastics patents. This section of 142 pages contains all relevant patents issued last year; they are collected in subject groups each of which is abstracted and prefaced by an expert, thus providing an indispensable record of technical developments in the industry. This same section also includes a list of the new plastics companies registered in 1956 and also British Standard Specifications relating to the plastics industry.

The up-to-date information provided in this one volume makes it invaluable to all connected with the plastics industry and to manufacturers and users of machinery and equipment.

Synthetic Fibers . . .

(Continued from page 65)

Another useful property of laminates reinforced or overlaid with synthetic fiber needled batt is their exact reproduction of the mold surface. It is possible to obtain laminates with an extremely smooth surface possessing a mirror-like finish. Needled batts of Orlon acrylic fiber, Dacron polyester fiber, or nylon not only provide this smooth laminate surface, but are an effective means of hiding the pattern produced by glass or other reinforcing fibers.

These property advantages were instrumental in the development and manufacture of plastic boats overlayed with Orlon. Needled batts of Orlon benefit both the manufacturing and performance of the plastic boats. In manufacturing, it reduces surface defects, particularly those encountered in areas of deep draw or at sharp corners. This is reflected in reduced finishing or repair work. In use these boats have better abrasion resistance, good weatherability, and improved surface appearance. These are important contributions to the durability and consumer acceptance of reinforced plastic boats. ★ ★

One-day Technical Conferences are soon being held in Detroit, Cleveland, Buffalo, Minneapolis and Los Angeles.

Topics are Foams, Compression Molding, Hot Runner Molding, Isocyanates, Polyethylenes and Plastics in Airborne Electronics.

The programs and dates appear in detail on pages 52 and 53.

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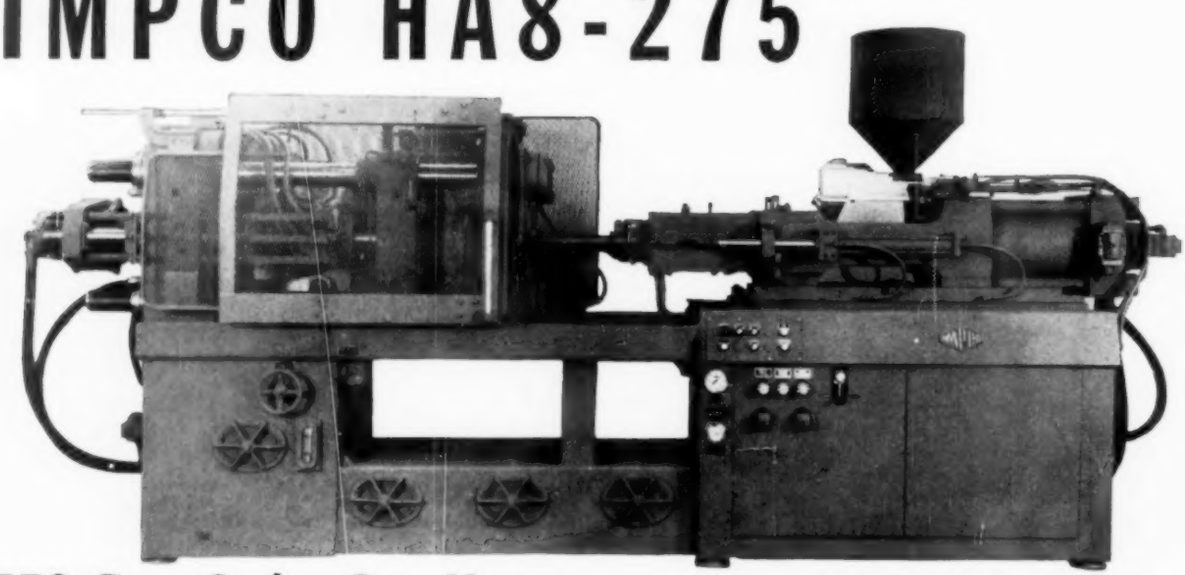

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By Wayne Pribble

A recent advertisement by Republic Aviation depicted a wolf looking longingly at a casual appearing porcupine. The copy said "Every wolf would like to eat porcupine. Few of them get around to it. What makes the porcupines' meat so good, of course, is the fact that he doesn't have to do any running. Wolves, by and large are an ill tempered, frustrated lot, while you almost never see a neurotic porcupine. He figures its cheaper to carry a quiver full of arrows than to get ulcers from hiding."

This rather amusing picture can find daily counterparts in the world of human beings. We forget to fill our quiver full of facts to be used as arrows in the battle with vice, corruption, intolerance and the whole host of other evils that should be driven out of society. The man who is well armed with facts and information has little to worry about. Of course, if you prefer to be ill-tempered and frustrated that is your privilege. Just remember that the cat has more friends than the lion.

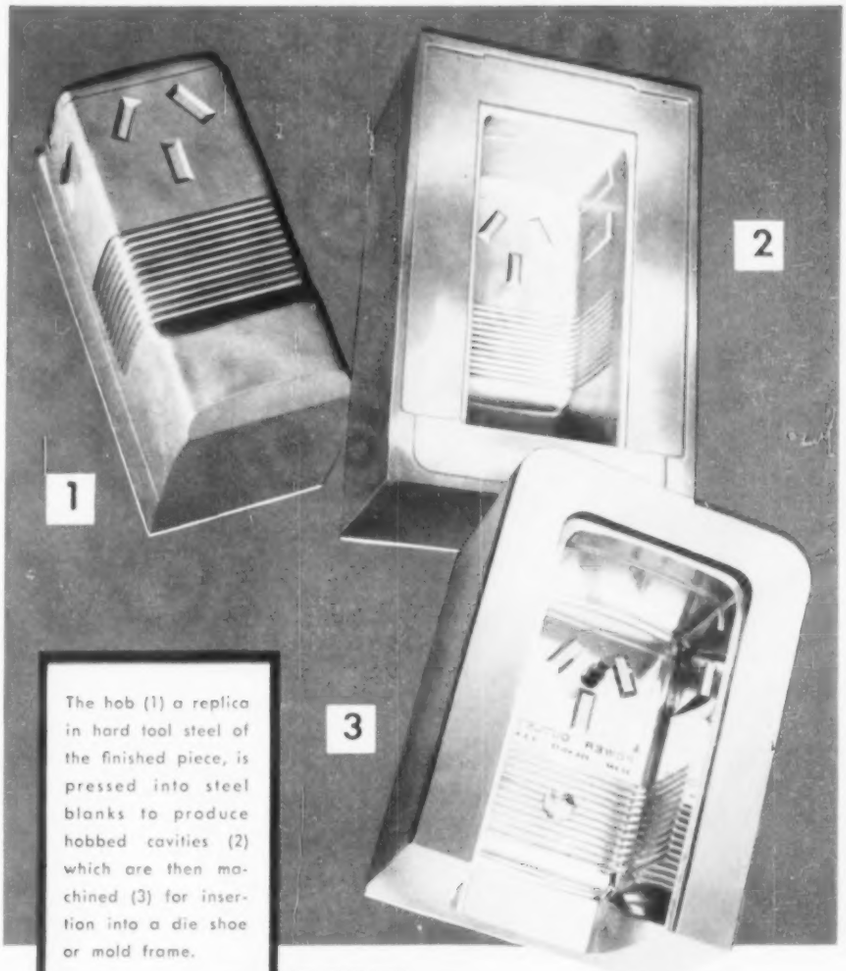
Yours for Better Living with Plastics

AROUND THE WORLD

(Continued from page 61)

Thomas Klinger

After a period of scepticism and resistance, radio chemistry, that is reactions which take place under the influence of atomic radiations, is becoming of greater interest. Atomic energy is still more costly than conventional forms of energy, but may be concentrated or applied in quite different manners. Alpha, beta, gamma and x-rays, accelerated electrons, mixed radiation from nuclear reactions and ultra sonics have all been used. Each results in the formation of ions and free radicals. Styrene, acetylonitrile, methylmethylacrylate, ethylene, polyvinyl chloride and acetate, methacrylic acid, methyl acrylate, vinylpyrolidone, acrylamide, butadiene, etc., have all been studied since the war in laboratories all over the world.



The hob (1) a replica in hard tool steel of the finished piece, is pressed into steel blanks to produce hobbed cavities (2) which are then machined (3) for insertion into a die shoe or mold frame.

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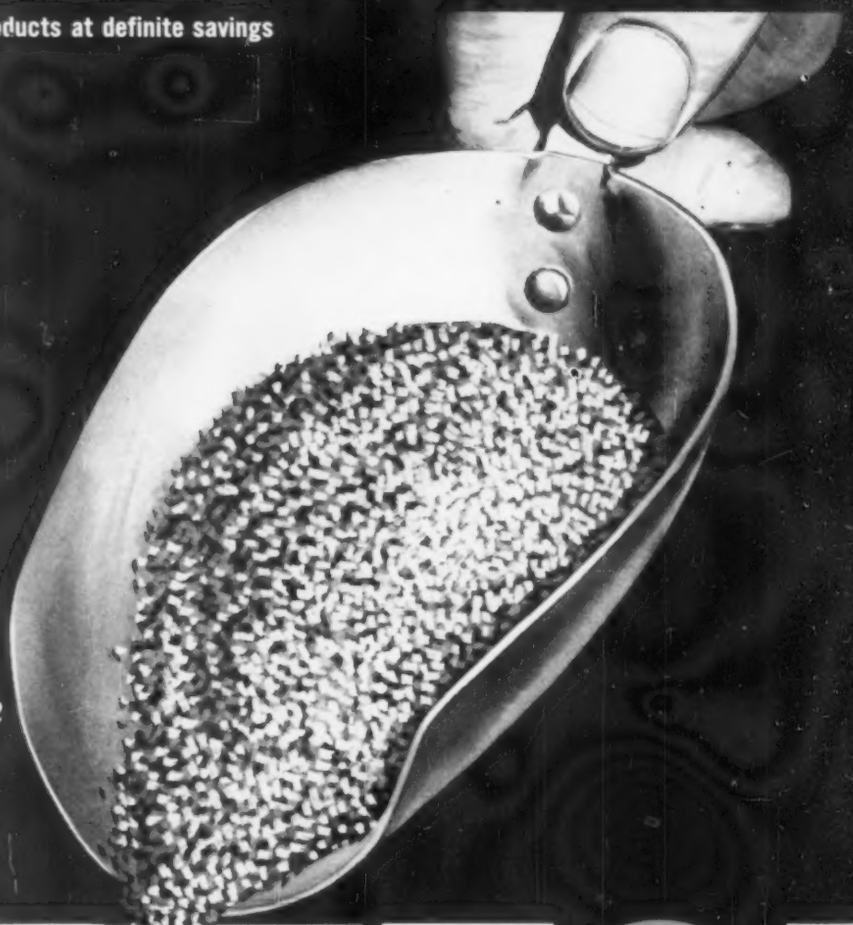

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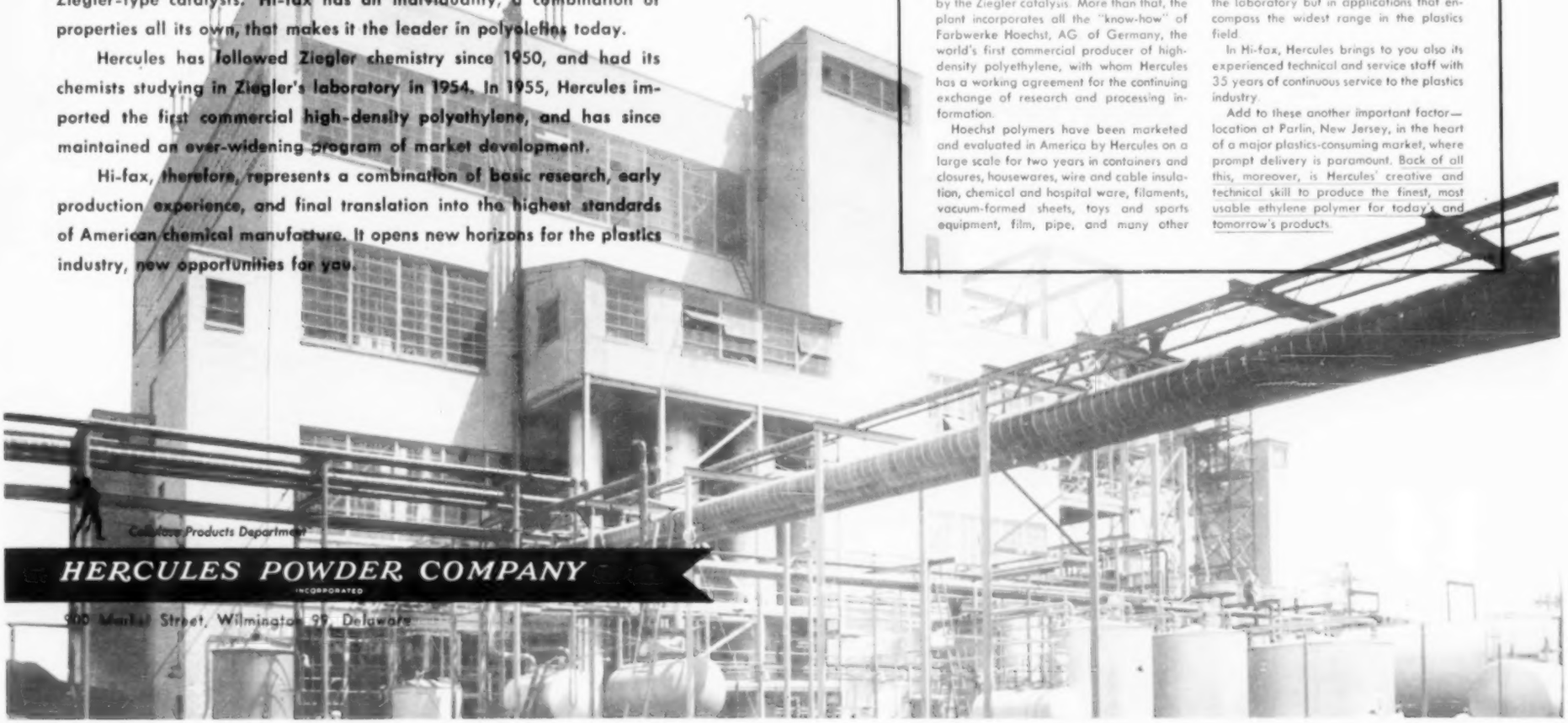

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